Machine and Tool BLUE BOOK

ESTABLISHED 1906

AIR POWER

JANUARY 1954

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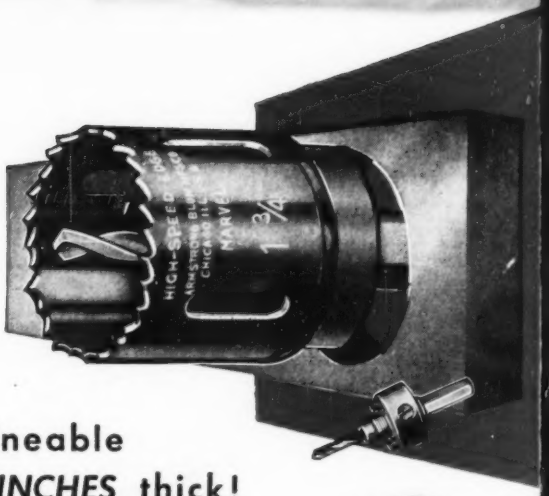


LARGE HOLES

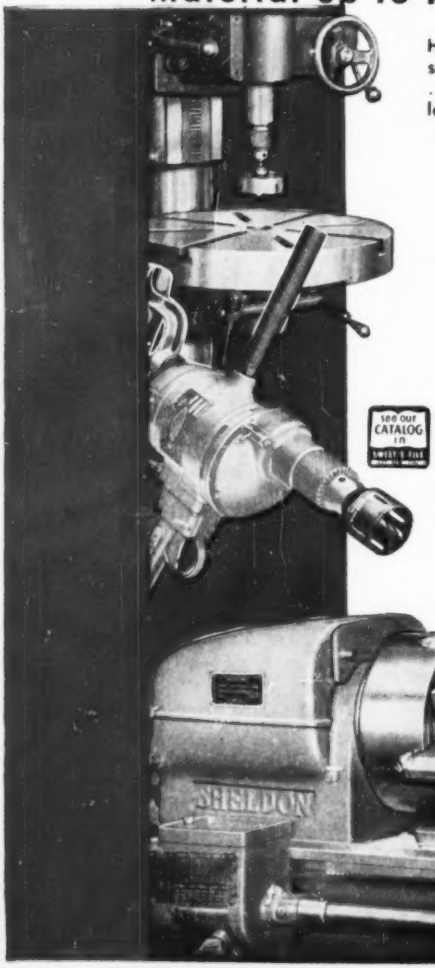
. . . thru any machineable material up to *1 1/8 INCHES* thick!

Here is a premium tool which makes it possible to saw holes in one short operation . . . large holes which heretofore had to be laboriously machined "a-chip-at-a-time."

MARVEL High-Speed-Edge Hole Saws have strength to withstand the terrific peripheral strains of heavy duty operation in lathes, drill presses or portable power tools. They have a high speed steel cutting edge which is electrically welded to a tough, alloy steel body, high speed steel pilot drills, heavy hexagonal shanked arbors and sufficient set for deep drilling. They are self-aligning, as the larger diameter saws float on their arbors and are driven by double drive pins. They will saw round holes accurately in any machineable material.

MARVEL High Speed-Edge Hole Saws come in 35 sizes, from 5/8" to 4 1/2". They are carried in stock by leading industrial distributors

WRITE FOR BULLETIN ST-49



See our CATALOG in SWEET'S FILE

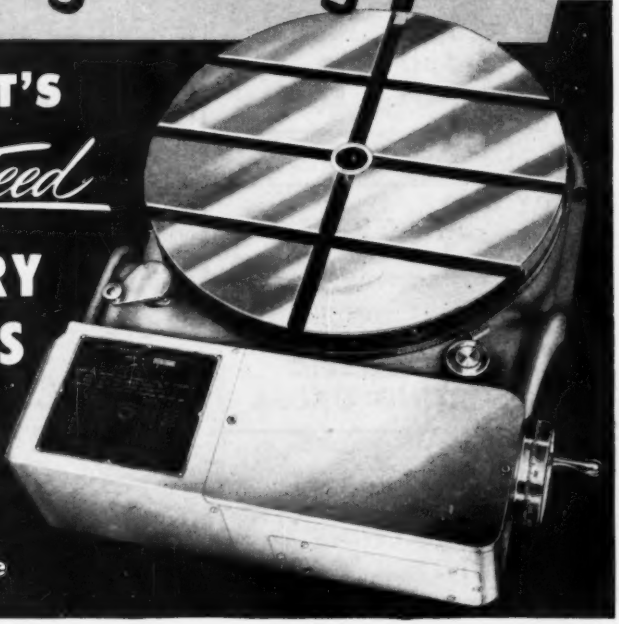
"MARVEL" *has Always had the edge!*

Metal Cutting **MARVEL SAWS**
Better Machines—Better Blades

ARMSTRONG-BLUM MFG. CO.
"The Hack Saw People"
5700 Bloomingdale Avenue **Chicago 39, U. S. A.**

Speed Up Your Rotary Milling Jobs!

KNIGHT'S *Power Feed* ROTARY TABLES



. . . For use on any vertical milling or boring machine

Complete self-contained motor driven units that adapt any vertical milling or boring machine for cycle milling and indexing . . . cam milling . . . production milling . . . continuous face milling . . . other jobs that require an automatic revolving fixture.

No setup time required—special equipment or adaptors unnecessary—no feed connection to machine. Plug them in to electric outlet and they're ready for work. An exceptional time and labor saver!

Mail Coupon For Brochure

W. B. KNIGHT MACHINERY CO.
3924 West Pine Blvd. • St. Louis 8, Mo.

January, 1954

20" MODEL—18 quick-feed changes, 1½" to 52", or 3" to 108"

42" MODEL—Infinite variable feed. Automatic positioning. Table can be increased to 60" with subplates.

KNIGHT VERSATILE MILLERS ACCURATE • RIGID

ATTACH TO COMPANY LETTERHEAD

W. B. KNIGHT MACHINERY CO.
3924 West Pine Blvd. • St. Louis 8, Mo.

Send information on Power Feed Rotary Tables.

Name.....

Title.....

☐ Also send details on Knight Milling Machines.

1

FEDERAL HAS EVERYTHING IN GAGES FOR DIMENSIONAL CONTROL

DIAL INDICATORS AND GAGES

Indicators — over 80 different models, ranges, sizes, graduations, styles — for every accuracy, space, and visibility requirement. Indicating Gages of all types including snap, hole, depth, caliper, etc., and special.

PICTURE PANEL GAGES

Multiple dimensions inspected simultaneously and quickly. (1) a single or individual light indicates at a glance if one or more dimensions are wrong. Or (2) separate lights identify incorrect dimensions and Dial Indicators show how much.

AIR GAGES

Federal Dimensionair: Greatest measuring range of any air gage — .003" with 2500 to 1 magnification. Most modern air gage. Available in various applications and combinations with Electrical and Electronic gages. Send for new complete catalog.

AUTOMATIC SORTING GAGES

Invaluable for selective assembly methods of production. Parts are measured and sorted into any number of dimensional categories with great accuracy and speed. 100% inspection without any possibility of human error. Semi-automatic or hand fed.

MACHINE CONTROL GAGES

Machine tool operations automatically and consistently size controlled — with exceptional accuracy. Also bare wire, insulated wire, glass tubing, steel rods, sheet, and similar continuous material is not only gaged in process but size-controlled by automatically adjusting the machine to compensate for variations out of tolerance.

ENGINEERING GAGE SERVICE

Federal can process engineer, design, and build complete sets of gages for any production job: Can often save money for you by modifying stock gages. Consult Federal before you process your next job. Save time and money and get better gages.

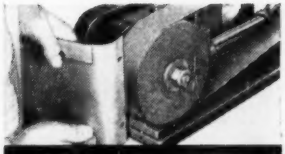
Call us in on the job when you start planning your gage requirements. You may find we've got some good ideas. Federal Products Corporation, 1251 Eddy Street, Providence 1, Rhode Island.

Largest manufacturer devoted exclusively to designing and manufacturing all types of DIMENSIONAL INDICATING GAGES.

DEBURRING Made Easy!

IRREGULAR SHAPES

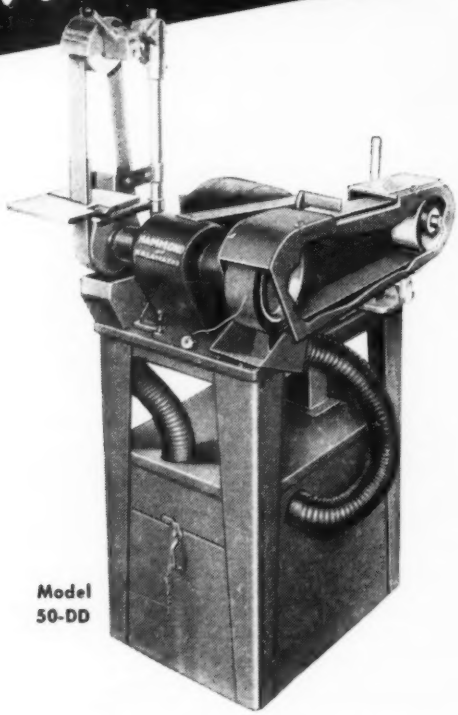
FLAT WORK



CONTACT WHEEL

CONTOURED PARTS

HARD-TO-GET AREAS



Model 50-DD

It is amazing how soon these Abrasive Belt Machines pay for themselves.

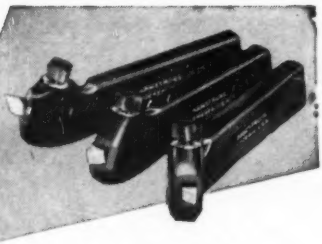
11 combinations available with or without Duskolector.

"Clip" this ad to your letterhead. 20 page catalog will be sent at once.

Hammond Machinery Builders INC

1614 DOUGLAS AVENUE KALAMAZOO, MICHIGAN

ARMSTRONG TOOL HOLDERS



answer both . . .

1. The problem of lowering costs

2. The problem of increasing output

By providing permanent, multi-purpose, inexpensive ARMSTRONG TOOL HOLDERS that use cutters or bits that are quickly ground from standard high speed shapes (Saving: All Forging, 70% Grinding and 90% High Speed Steel), the ARMSTRONG System of Tool Holders will reduce your tool cost to an absolute minimum.

By providing stronger, more efficient tools, carefully developed for each operation, as well as ARMSTRONG High Speed Steel. ARMALOY Cast Alloy Cutter Bits or Armide Carbide-Tipped Cutters as required for each job. ARMSTRONG TOOL HOLDERS permit greatly increased speeds and feeds, enable you to increase the hourly output of every lathe, planer, slotter, shaper, turret lathe and screw machine.

There is no surer way to lower costs and increase output, than to use the correct ARMSTRONG TOOL HOLDER for each operation on all machines.

ARMSTRONG BROS. TOOL CO.

"The Tool Holder People"

5208 W. Armstrong Ave. Chicago 30, U.S.A.

Eastern Warehouse and Sales: New York 12, N.Y.
Pacific Coast Whse. & Sales Office: San Francisco 3, Calif.

Machine and Tool
BLUE BOOK
Jet POWER ISSUE

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Hitchcock Managers are Listed on Page 64

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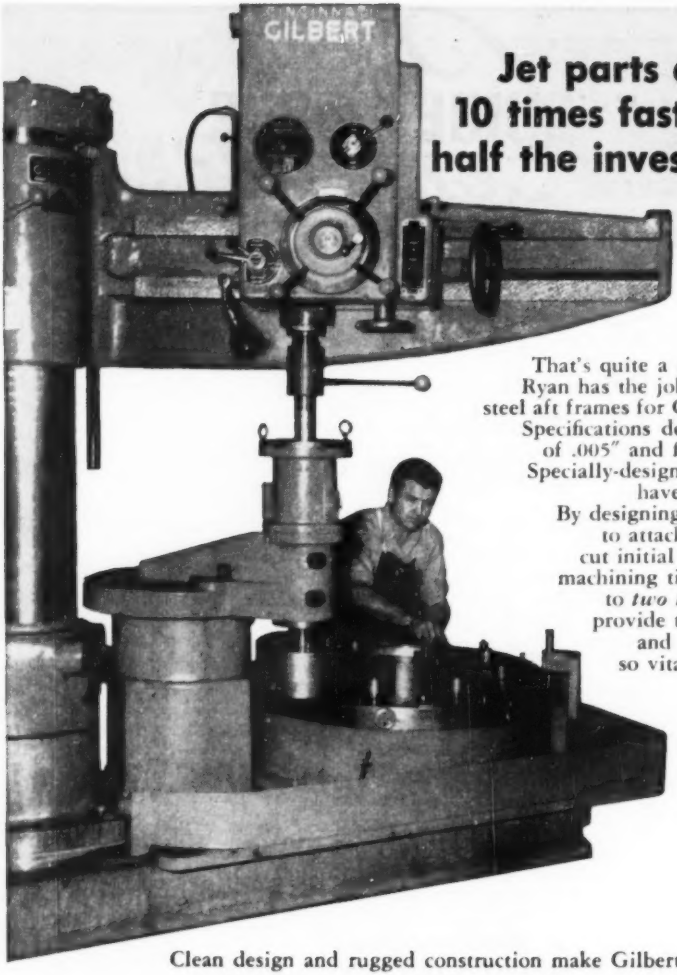


Jet parts drilled 10 times faster for half the investment

That's quite a story. But it's true. Ryan has the job building stainless steel aft frames for GE J-47 jet engines. Specifications demanded tolerances of .005" and finishes of 63 RMS. Specially-designed machines would have cost $40,000 each. By designing their own fixtures to attach to Gilberts, Ryan cut initial investment in half, machining time from two days to *two hours*. The Gilberts provide the rigidity, power, and responsive controls so vital to precision jobs.

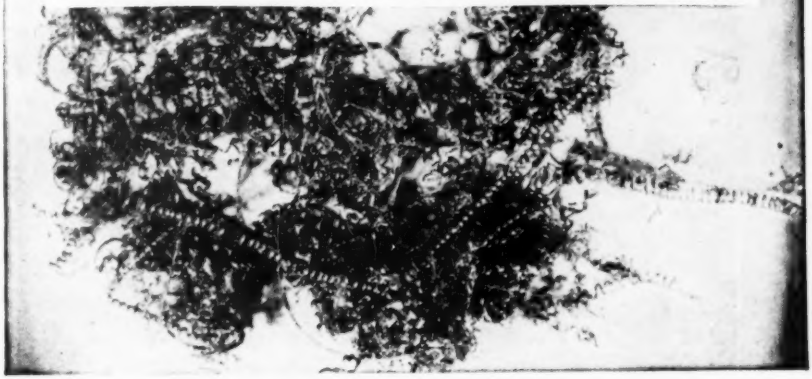
Clean design and rugged construction make Gilberts pay high returns on your investment. Quick response to controls, with minimum effort, plus positive "no-drift" clamping, help Gilbert operators get more work done accurately and faster. 9" and 11" columns. Thirty-day delivery. Ask your Gilbert representative to demonstrate why "those who buy Gilbert buy Gilbert again," or write for Bulletin 349.

GILBERT

THE CINCINNATI GILBERT MACHINE TOOL COMPANY • 3366 BEEKMAN STREET, CINCINNATI 23, OHIO

Believe it or not . . .

THESE ARE HONING CHIPS



FULMER

HONING MACHINES REMOVE METAL SO RAPIDLY THAT ONLY ROUGH BORING OR DRILLING IS NEEDED BEFORE HONING

Think of the terrific savings in time and labor! In Fulmer Honing Machines the spindle rotating and reciprocating mechanism provide honing of geometrical accuracy and any desired degree of smoothness. The rapid cutting action removes large amounts of material quickly, as shown in the photograph, with chips as long as 6 inches.

FULMER COMPLETE HONING EQUIPMENT Has EVERYTHING YOU NEED IN ONE "PACKAGE"—Honing Machines—Tools—Fixtures—Stones

. . .

WRITE for bulletin on HONING

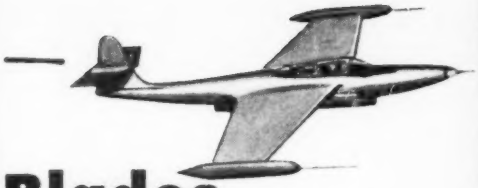
C. ALLEN FULMER CO.

1242 FIRST NATIONAL BANK BLDG. CINCINNATI 2, OHIO

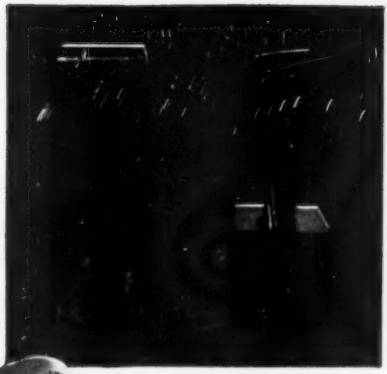
Milling Airfoil Profile on Jet Engine Six at a

One of the many critical machining operations on jet engine parts is that of producing an accurate airfoil profile. This is accomplished to a high degree of accuracy and at low cost with the CINCINNATI Six-Spindle Blade Milling Machine illustrated here. ¶ The machine is inclined at a 45° angle to facilitate work handling. To mill six parts at one time, there are six spindles, six rotating work heads and one rotating master head. Automatic hydraulic depth-tracing controls the table movement. The milling operation proceeds automatically, feeding from the top to the root section of the blade, with precise duplication of the airfoil profile. ¶ CINCINNATI'S automatic hydraulic depth control system of machining irregular shapes is applicable to many milling operations other than die sinking. Coupled with our extensive experience in tracer controlled milling and the wide variety of sizes, types and styles of CINCINNATI Milling Machines, this method of machining offers new opportunities for cost reduction in areas hitherto bound by tradition. Our Application Engineers will be glad to give you the benefit of their experience. Send blueprint of part and complete methods data.

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO

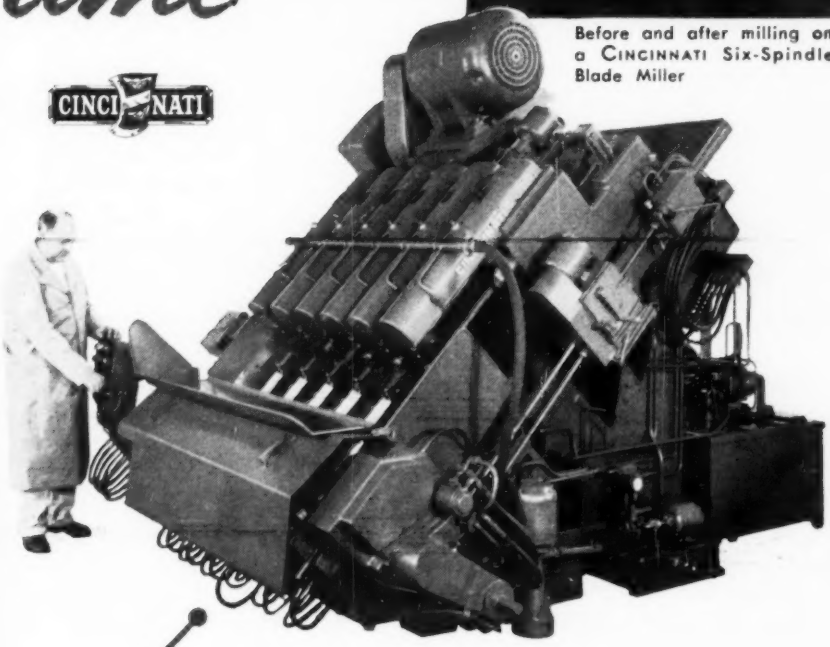


Blades *time*



Before and after milling on a CINCINNATI Six-Spindle Blade Miller

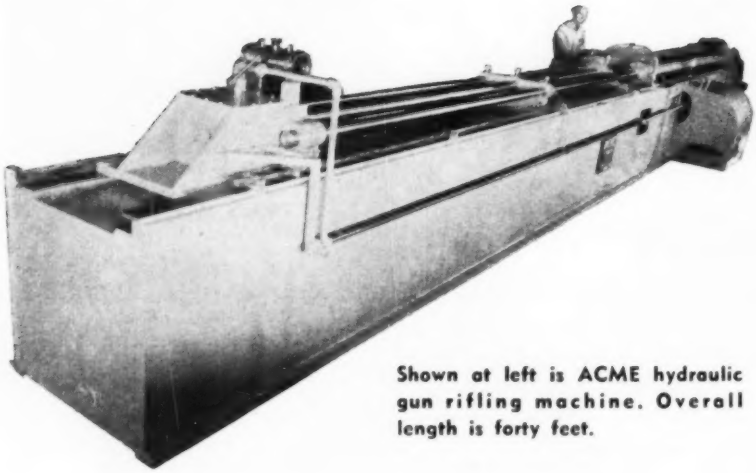
CINCINNATI



CINCINNATI

MILLING MACHINES • CUTTER SHARPENING MACHINES • BROACHING MACHINES • METAL FORMING MACHINES • FLAME HARDENING MACHINES OPTICAL PROJECTION PROFILE GRINDERS • CUTTING FLUID

WE CAN BUILD 'EM BIG, TOO –



Shown at left is ACME hydraulic gun rifling machine. Overall length is forty feet.

Large hydraulic machines are nothing new to ACME engineering and manufacturing. In addition to a complete line of hydraulic broaching machines and hydraulic presses we also manufacture a wide variety of gun rifling equipment for many sizes of bores to produce either constant or accelerated lead grooving.

Why not take advantage of this source of experience when next you need broaching or rifling equipment?

ACME BROACH CORP.

MILAN, MICHIGAN

another cost saving performance record set by the GRAY PLANER CUB

Former planing time of steel bars and gibs was cut to ⅓ when this high speed GRAY PLANER CUB was put into action at a leading Midwestern metal fabricating plant.

This is accomplished by the Cub's high speed, greater power and tremendous rigidity—all essential to heavy duty carbide steel planing.

Proof of outstanding performance is the fact that this company has two more Cubs on order. Built in 24" — 30" — 36" sizes. Write for Bulletin 55.

the job: planing hi-carbon, hi-chrome steel bars

cut speed 160' per min. • return speed 300' per min. • two heads • depth of cut 3/32" • feed .040

The G.A. GRAY Company

planers · milling planers
planer type milling machines
horizontal boring machines

Dept. D

CINCINNATI 7, OHIO, U. S. A.
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Users report excellent results with New Sunicut S Oils

In just six months, these unique new straight cutting oils have "Job Proved" themselves as top performers in many metalworking shops all through the industry.

From the field, reports like these keep coming in:

LARGE IMPLEMENT MANUFACTURER TELLS US, "We get better finishes in our broaching operations with Sunicut 110-S, and our operators favor its light color."

SCREW MACHINE SHOPS REPORT, "The versatility of Sunicut 209-S permits us to reduce the number of oils we must stock."

AN AUTO PARTS MANUFACTURER INFORMS US, "Threaded parts are as much as 50° cooler when they come off the machines. And our operators like the clear, clean, odorless qualities of Sunicut 102-S."

BROWN & SHARPE SCREW MACHINE OPERATORS SAY, "Sunicut 11-S increases tool life, gives finer finishes, eliminates staining problem."

Let us show you how these new Sunicut S Oils can help you. For technical bulletins or the services of a Sun representative, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Department MT-1.

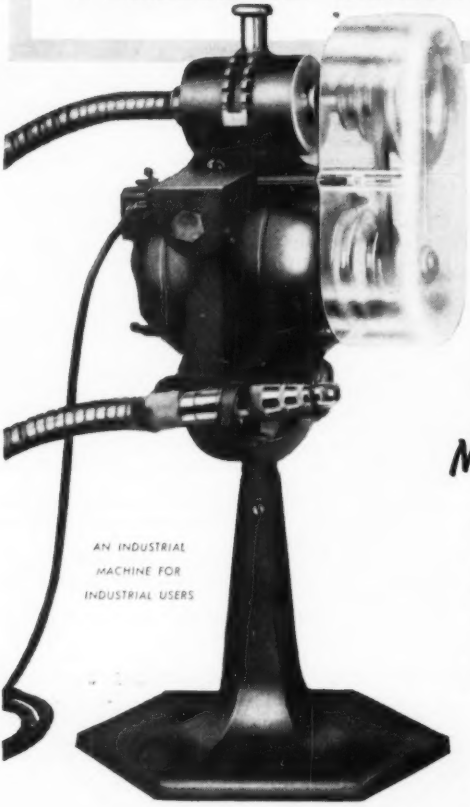
INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

SUNOCO

PHILADELPHIA 3, PA. SUN OIL COMPANY LTD., TORONTO & MONTREAL

POWERFUL
FLEXIBLE SHAFT MACHINES



AN INDUSTRIAL MACHINE FOR INDUSTRIAL USERS

by **Jarvis**

Do Your Jobs

EASIER -- FASTER -- MORE ECONOMICALLY!

Whether your operations call for GRINDING, CUTTING, BUFFING, SANDING or ROTARY FILING, Jarvis Flexible Shaft Machines are available in BENCH, FLOOR or OVERHEAD Types — in Single or Multiple Speeds to suit your Individual Requirements.

A Jarvis Factory Trained Representative will be pleased to assist you in selecting models best suited to your use. Complete catalog upon request.

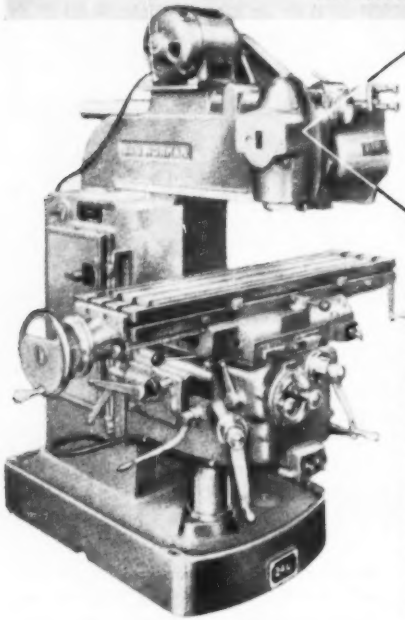
TAPPING ATTACHMENTS · TAPS · FLEXIBLE SHAFTS AND MACHINES · ROTARY FILES · TUNGSTEN CARBIDE REAMERS AND MILLS · DRILLS · BORING BITS

Jarvis POWER TOOLS

THE CHARLES L. JARVIS CO.
MIDDLETOWN IN CONNECTICUT

New 10 MODELS VAN NORMAN Ram Type Milling Machines

Providing Maximum "Flex-Ability" and "Cut-Ability"
...Will REDUCE Milling Costs!



No. 24L shown is 1 of 10 new models

Adjustable cutterhead permits horizontal, vertical as well as angular milling on one machine.

Van Norman Plus Features

"Flex-Ability" is increased with the *new*, improved heavy-duty adjustable cutterhead which has 90° adjustment . . . permits horizontal, vertical as well as angular milling.

"Cut-Ability" is increased with the *new* box type column, with its heavier and wider cross sections whose internal ribbing provides utmost rigidity. This generous ribbing provides maximum strength, assuring rigid support for the extra long ram, as well as the heavy knee.

"Cut-Ability" is increased with the *new* heavy motorized knee. The direct drive feed motor is mounted on the knee. The 10 models provide a selection of horsepower from 3 to 10.

"Flex-Ability" is increased with the *new* extended, large, heavy-duty ram, which increases the capacity of the miller . . . permitting maximum cuts over the entire ram range to the full capacity of the motor.

"Cut-Ability" is increased with the *new* heavy knee, saddle and table assembly . . . designed as a unit to provide maximum rigidity and accuracy.

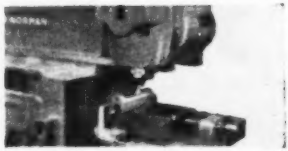
"Flex-Ability" is increased by the spindle motor that drives cutterhead only . . . permits every type of milling with all types of cutting tools.

Write for more information about these new Van Norman Ram Type Milling Machines.

Maximum "FLEX-ABILITY" with the VAN NORMAN Adjustable Cutterhead

A typical horizontal milling operation performed on the new Van Norman Ram-type Miller.

An angular milling operation performed on the same work piece. Note work piece remains in the same set-up. Angular range of cutterhead 0°-90°.

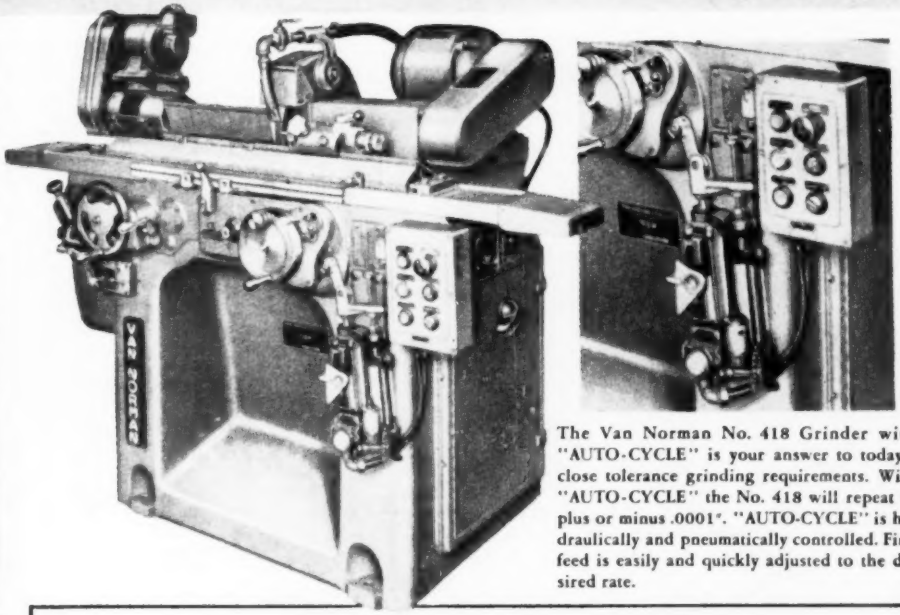


With the cutterhead locked in vertical position a slot is milled in the work piece. Note the set-up has not been changed.

VAN NORMAN — manufacturers of — Ram and Column Type Milling Machines, Cylindrical Grinders, Spline Grinders, Oscillating Radius Grinders, Special Production Grinders, Centerless Grinders.

New "AUTO-CYCLE" INFEED ATTACHMENT

provides Completely Automatic cycle for plunge grinding on Van Norman No. 418 Cylindrical Grinders



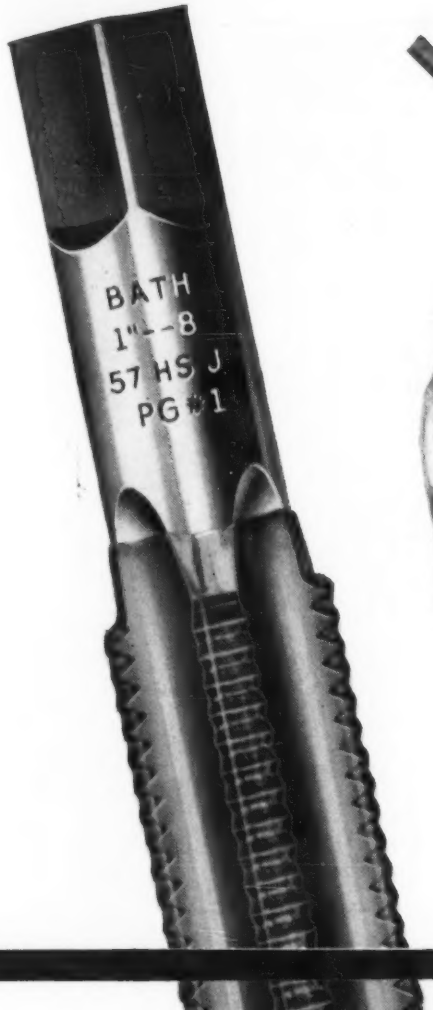
The Van Norman No. 418 Grinder with "AUTO-CYCLE" is your answer to today's close tolerance grinding requirements. With "AUTO-CYCLE" the No. 418 will repeat to plus or minus .0001". "AUTO-CYCLE" is hydraulically and pneumatically controlled. Fine feed is easily and quickly adjusted to the desired rate.

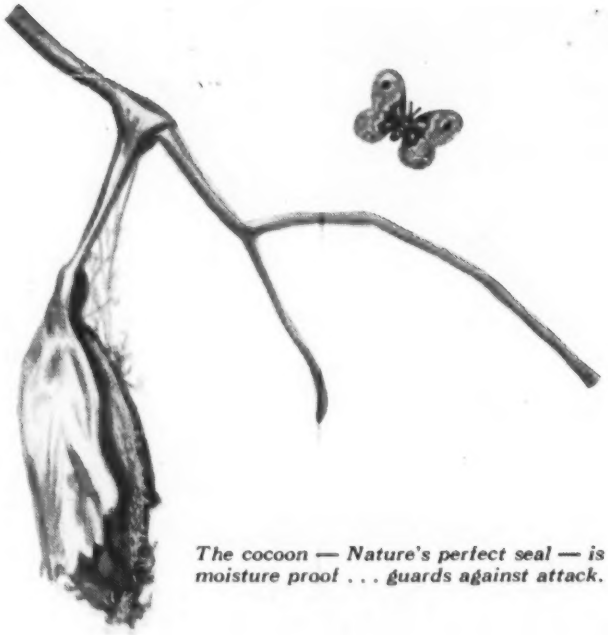
Plus Features on the No. 418 Grinder

- Wheel spindle is of unit type construction — totally enclosed with double row precision cylindrical roller bearings, proved on thousands of Van Norman Grinders, assuring maximum accuracy and long operating life.
- Heavy-duty headstock and footstock for rigidity, accuracy and smooth grinding.
- Automatic starting and stopping of headstock and table traverse.
- Rugged base, with wide table bearing ways. Separate motor drives for wheel spindle, table and headstock.
- Controls are conveniently grouped in front of grinder for ease of operation.
- One-shot metered lubrication for all bearing surfaces on ways.
- Capacity 4" x 18". Can be purchased with or without "AUTO-CYCLE".

Write for complete information. Ask for prices. They're remarkably low for such high quality equipment.

VAN NORMAN COMPANY, Springfield 7, Massachusetts





The cocoon — Nature's perfect seal — is moisture proof . . . guards against attack.

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You can always be sure that Bath Taps come out of the stockroom FACTORY FRESH! No chance of damage during shipment, handling or storage — because

the "business end".

damage during shipment, handling or storage — because the "business end".

This man-made cocoon, seals in all the original manufacturing craftsmanship and engineering precision of these fine tools — from factory to user. It's moisture proof, too — guards Bath Taps against attack by rust — protects sharpness and cutting efficiency.

Whether you leave them in "moth balls" for minutes or months — you'll find Bath Taps packaged for your protection in the most modern way — a mighty important extra service.

If you do not already know him — we'll be glad to put you in touch with a Bath representative nearby, who will help you with your threading problems.

Removing the protective seal from Bath Taps is like peeling the skin of a banana!

Insist on BATH TAPS for BETTER THREADS

JOHN BATH & CO., Inc.

14 Grafton St., Worcester, Mass.

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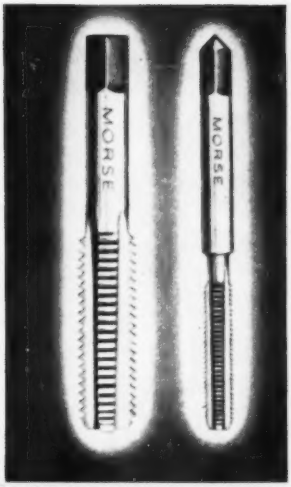
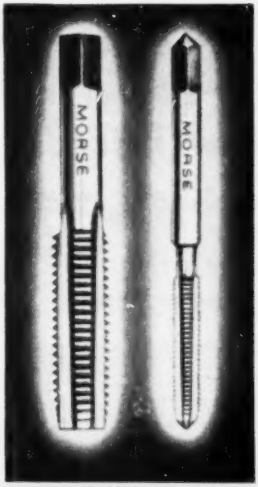
"We never knew what Special-Purpose Taps could do . . . 'til we got these NEW MORSE TAPS!"

MORSE



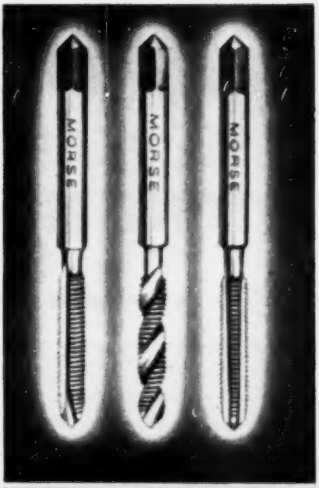
For Brass or Cast Iron

For use in these and other materials with *brittle-chip* characteristics . . . in hand, machine-screw, and taper-pipe styles. Made with radial face (0 degrees rake — see drawing at right below) and surface-treated to resist abrasion and loading. High-speed steel with commercial ground threads only, except for pipe taps (also furnished with cut threads.)



For Aluminum or Stainless Steel

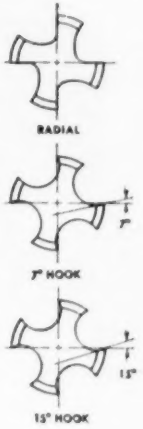
For use in these and other materials with *stringy-chip* characteristics . . . in hand, machine-screw, and taper-pipe styles. Made with a 15-degree hook (see center drawing at right below) and commercial ground threads, in high-speed steel only.



Oversize Machine-Screw Taps

For use in materials like plastics or zinc alloys, *where difficult to maintain proper tapped-hole size* . . . because of the material's abrasive properties or its tendency to shrink, *after tapping*. Made in certain sizes only . . . in straight-flute . . . spiral point . . . and spiral flute styles. Regularly furnished .002" over standard commercial ground-thread limits. Surface-treated to resist abrasion.

HERE'S THE BIGGEST TAP NEWS IN YEARS . . . and as usual it comes from Morse. These new Special-Purpose Taps . . . set new standards of performance and long life. Get the whole story on this new Morse line *direct and in person* . . . from your experienced Morse-Franchised Distributor, who is always at your service. He has an important new free booklet for you . . . giving complete details on these new Morse Special-Purpose Taps, and full information on the new Unified Threads.



MORSE TWIST DRILL & MACHINE COMPANY
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Warehouses in New York, Chicago, Detroit, Houston, San Francisco

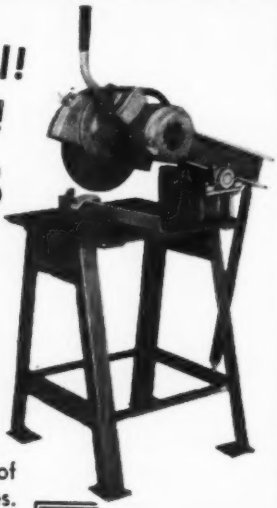
Cutting Tools

IT'S NEW! It's Powerful! It's Low Priced!

STONE Model M-35

12" Cut-Off Machine

For Ferrous and Non-Ferrous Metals



CAPACITY
Ferrous—1½" solids, 2½" O.D. pipe, 2½" structurals
Non-ferrous—2½" solids, 3" tubing and extrusions

We are proud to present the newest member of our superior line of high speed cut-off machines. The M-35 has a full 3½ h.p. geared-in-head motor. The direct drive insures delivery of full power to the cutting edge. Result — faster cutting (3 seconds per square inch of metal) and greater wheel life.

PRICE
Completely Equipped Ready for Cutting

$445

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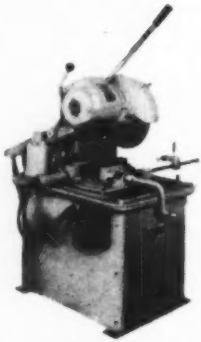
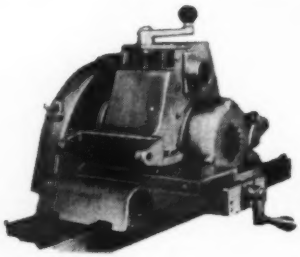


MODEL M-75
Full 7½ h.p. geared-in-head motor. Will cut all ferrous and non-ferrous solids up to 2½", pipe and structurals up to 4". Can be equipped for wet cutting.



MODEL SS-20
Operates on guided rails for cutting larger structural steel, plate, sheets, with cuts up to nine feet in length. Cuts wet or dry.

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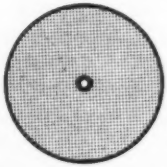
Cut 25% faster — average cutting time is 3 seconds per square inch of metal. Increased wheel life up to 25%. Write for prices.



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Why Pay Fancy Prices for MAGNETIC CHUCKS?

Supplied with connections for either 110 or 220 volts D.C.

Grip Work Tightly for Wet or Dry Grinding

Guaranteed Waterproof

5¾" x 13" **$55.37**

6½" x 18" **$73.40**

8" x 24" **$146.00**

10¾" x 37" **$280.00**

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A single pass over the stationary poles completely demagnetizes work. 110 volt A.C. Model B-2 for large work, 7¾"x12½"x6¾". Ship. Wt. 55 lbs. **$73.45**

Model J-1 for small work, 7¼" x 7¼" x 6¾". Ship wt. 35 lbs. **$47.83**

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Field discharge type for 8" x 24" and 10¾" x 37" **$18.90**

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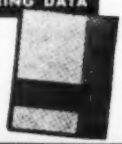

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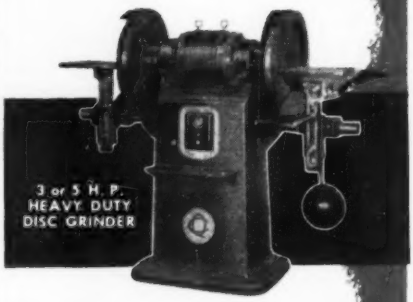

Queen City Heavy Duty Disc Grinders and Buffers are designed for the hardest use. Extra heavy spindle, large, high quality ball bearings and special duty motors all contribute to long, trouble-free service.

The complete range of Queen City Grinders and Buffers . . . floor and bench types . . . in sizes from ⅓ to 10 H. P. . . . is described in a free 24-page catalog.

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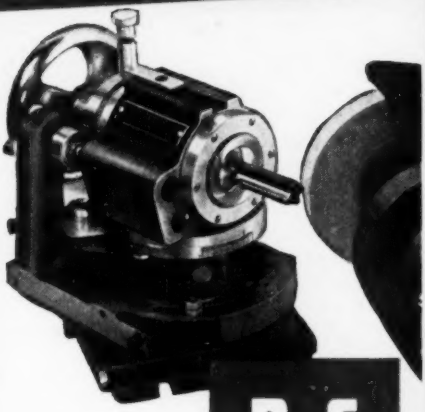

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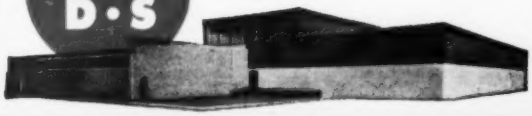

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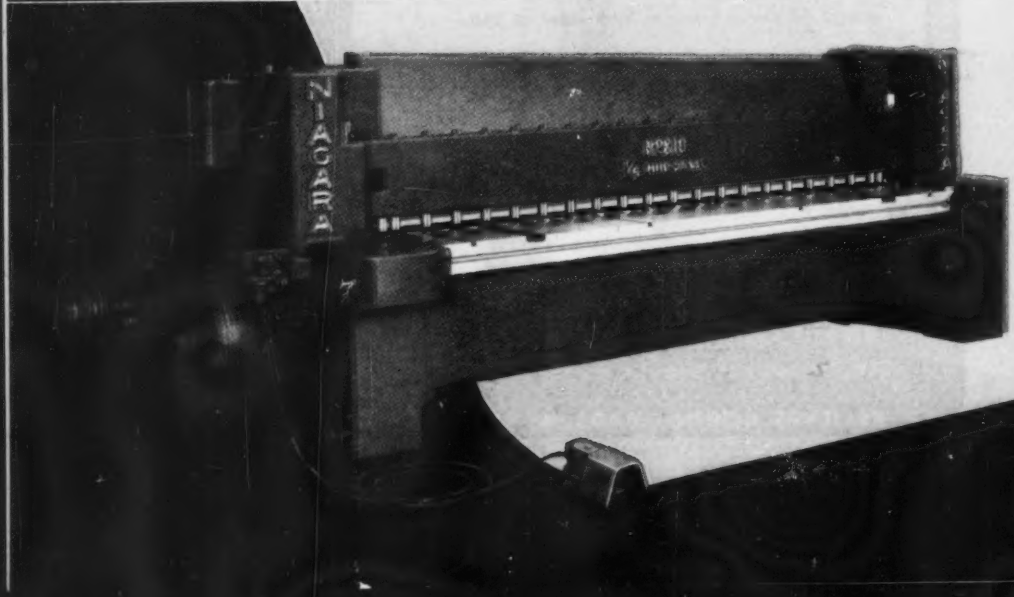

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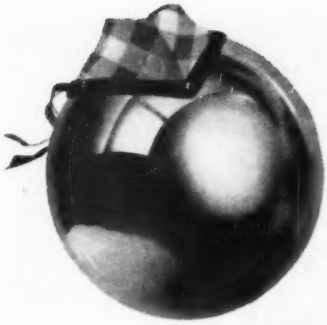
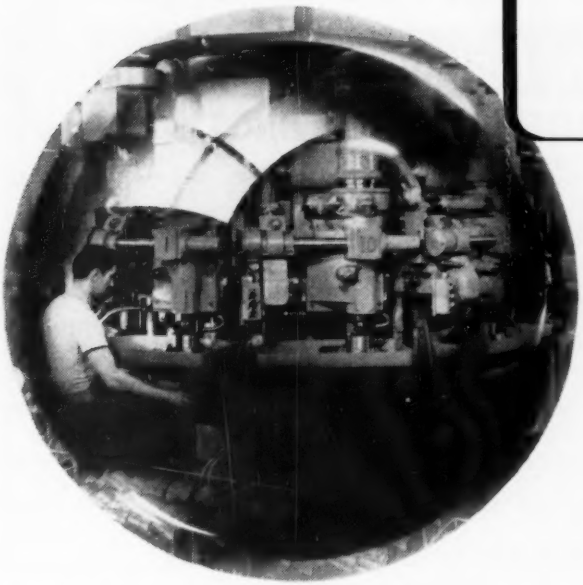
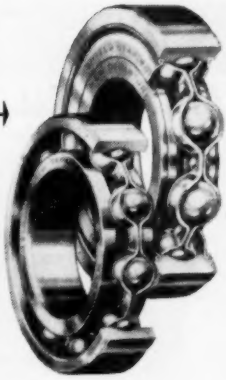


Money Savers in Motors and Machinery





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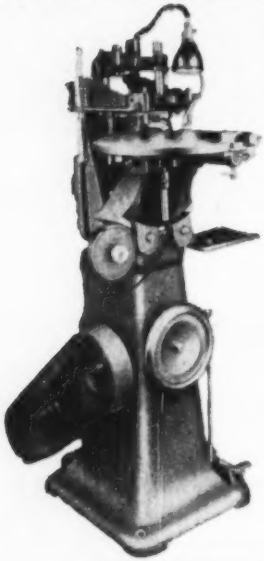

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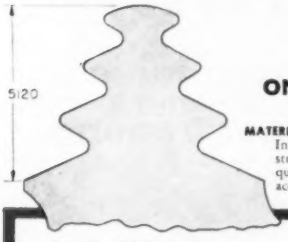

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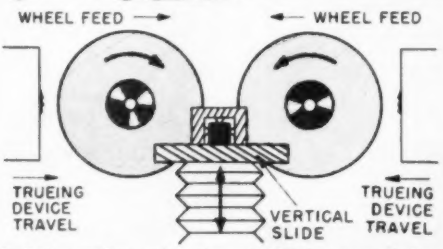

Bucket is mounted on a reciprocating vertical slide for two-way grinding.

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Spacing of pressure surfaces within .0002
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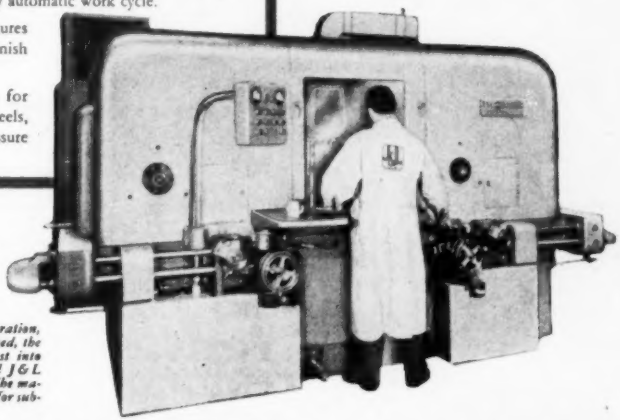

Before the grinding operation, the foil contour is checked, the blade oriented and cast into a matrix, on a special J & L Optical Comparator. The matrix serves as a fixture for subsequent operations.

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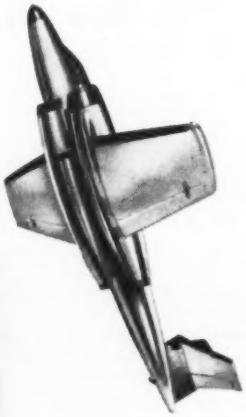

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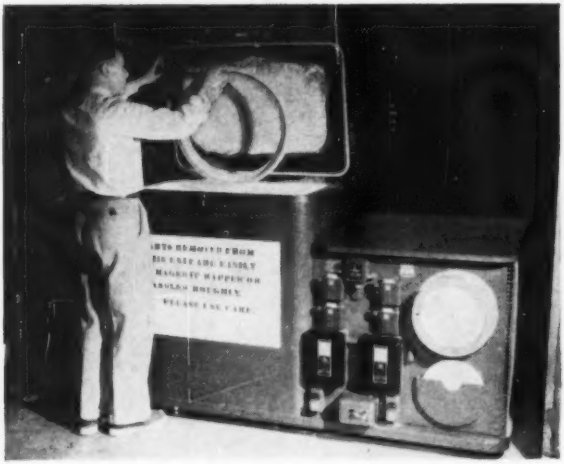

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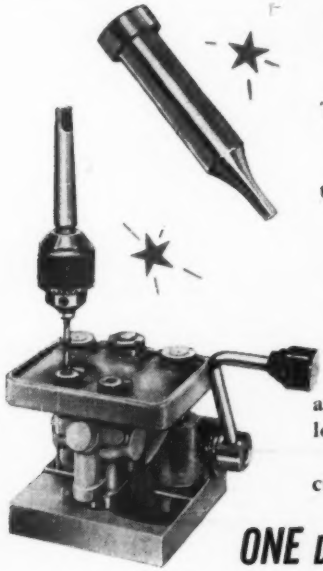

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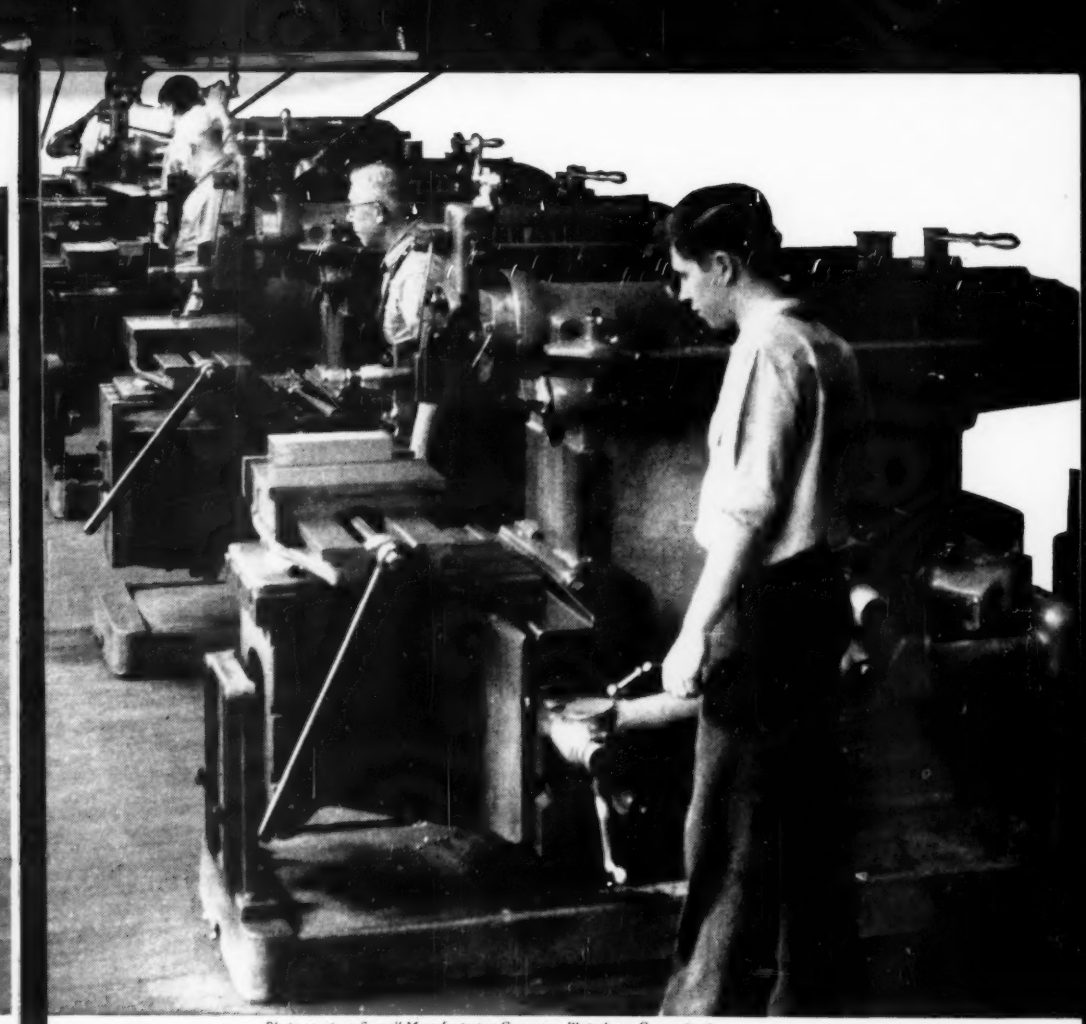

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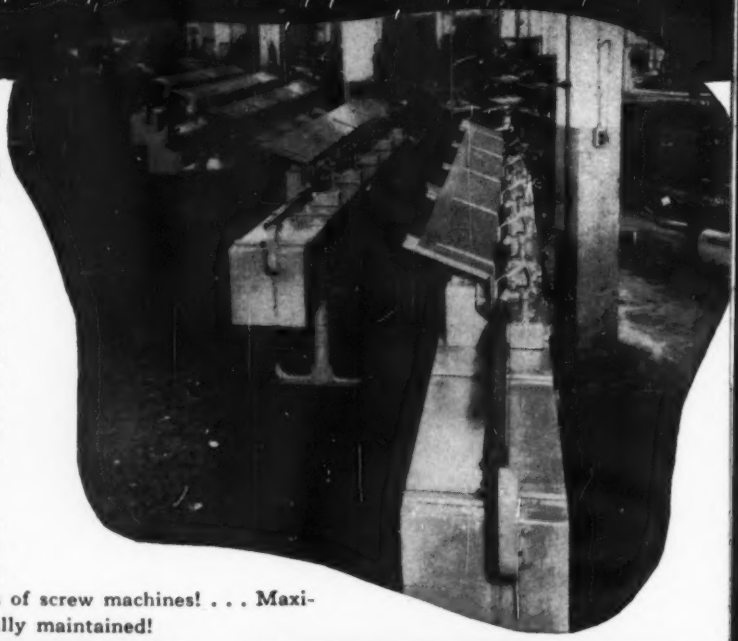
LIPE AUTOMATIC MAGAZINE LOADING BAR FEEDS *Doubled* PRODUCTION!



THE machined worm wheel shaft and agitator rod shown below are typical of the many parts turned out on a bank of seven screw machines equipped with Lipe AML Bar Feeds at Hamilton Beach Division, Scovill Mfg. Co., Racine, Wis., manufacturers of food mixers, vacuum cleaners, hair dryers and other motorized appliances.

No lost time in loading and hand feeding! . . . No scratching of high-finish stock! . . . No idle operation of screw machines! . . . Maximum production capacity fully maintained!

Long worm wheel shaft .3125" dia. machined from piston rod finish, cold-drawn steel. When the Lipe AML Bar Feed automatically loaded and fed the stock to a Model 2G B&S, *production increased* 100% over conventional loading operation.

Agitator rod .250" dia. machined from S.A.E. #1112 Bessemer wire. When the Lipe AML Bar Feed automatically loaded and fed the stock to a Model 00G B&S, *production increased* 100% over conventional loading operation.

On job after job there is proof—like these examples from a typical four-week production run—that Lipe Automatic Bar Feeds insure big production gains, BECAUSE:

- **Stock is fed to screw machines all the time . . . not dependent on operator.**
- **Feed pressure constantly behind stock.**
- **Eliminates feed fingers.**
- **Avoids multiple feed finger feedouts.**
- **Model AML gives maximum output of machine . . . no "cutting air."**
- **Saves change-over set-up time.**

Get full details on how this machine will increase production and save you money. It's today's big advancement in screw machine stock feeding. Our engineers will gladly study your problem . . . no obligation.

LIPE ROLLWAY

Lipe - ROLLWAY CORPORATION

Manufacturers of Automotive Clutches and Machine Tools

Syracuse 1, N. Y.

the *tougher* the cutting job . . .
the *better* the opportunity for . . .

Abrasive Cutting

We question the judgment of G. I. Joe, but even the General knows that Allison Wheels cut rings around competition. Fact is, whatever the material or the conditions, there's an Allison Abrasive Wheel that does a more economical and efficient cutting job. Steel, non-ferrous metals, bar stock, tubing . . . whatever it is, Allison Wheels cut cleanly at high speeds.

For complete information on wet or dry cutting, ask Allison . . . *specialists in abrasive cutting* for 30 years.

Allison ABRASIVE CUTTING WHEELS

THE *best* WAY TO CUT MANY MATERIALS

THE *only* WAY TO CUT SOME

SEND FOR THIS HELPFUL BOOK ON ABRASIVE CUTTING

THE ALLISON COMPANY
264 Island Brook Ave., Bridgeport 8, Conn.
Please send me your free booklet on Abrasive Cutting:
NAME: _____
ADDRESS: _____

SALES

with a **WIEDEMANN** you can

Reduce INVENTORY and STORAGE SPACE!

produce parts as required.

All

38

PIECES

were pierced

in

⅛" mild steel

IN

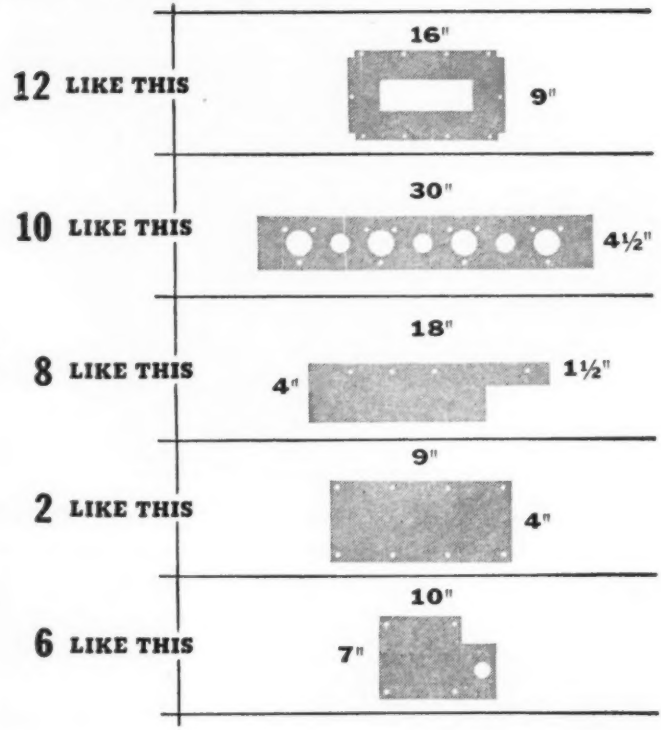
28

MINUTES

(including

all

set-up)



The company producing the above parts has eliminated inventory of these and many other items, has greatly reduced inventory of punches and dies—and they no longer need to stock templates.

The Wiedemann method enables them to ship parts directly to assembly rather than the stockroom.

Items are produced weekly or more often if necessary. Sizes of parts pierced on the Wiedemann range from 5 ft. by 10 ft. down to 2 in. squares.

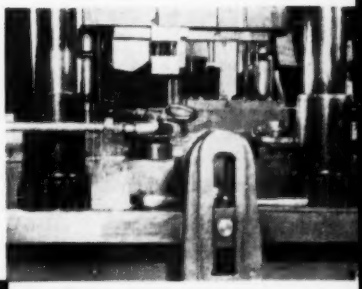
Inventory and storage reduction are just two of many cost-reducing features of Wiedemann Turret Punch Presses. We'll gladly make a time study on your own work.

WIEDEMANN MACHINE COMPANY

4265 WISSAHICKON AVENUE, PHILADELPHIA 32, PA.

Ekco DEPENDS ON DANLY to save tooling time!

This popular basting spoon is one of thousands of famous household items made by Ekco Products Company in dies mounted in Danly Die Sets. Ekco depends on Danly Die Sets to save costly tooling time and help maintain uninterrupted production schedules in this highly competitive industry, because Danly Die Sets provide the finest *precision* starting point for diemaking. They are available on short notice from a completely stocked Danly assembly plant nearby.



Call Your Local Danly Branch Today!

***CHICAGO** 50 2100 S. Laramie Ave.
***CLEVELAND** 14 1550 East 33rd St.
***DAYTON** 7 3196 Delphos Ave.
***DETROIT** 16 1549 Temple Ave.
***GRAND RAPIDS** 113 Michigan St., N.W.
INDIANAPOLIS 4 5 West 10th St.
***LONG ISLAND CITY** 47-28 37th St.
***LOS ANGELES** 54 Ducommun Metals & Supply Co., 4890 South Alameda
MILWAUKEE 2 111 E. Wisconsin Ave.
***PHILADELPHIA** 40 511 W. Courtland St.
***ROCHESTER** 6 33 Rutter St.

**Indicates complete stock*

DANLY

DIE SETS STANDARD OR SPECIAL
DIEMAKERS SUPPLIES

DANLY MACHINE SPECIALTIES, INC.
2100 South Laramie Avenue
Chicago 50, Illinois

any way you look at it . . .

portable grinding is profitable grinding with SIMONDS resinoid bonded grinding wheels

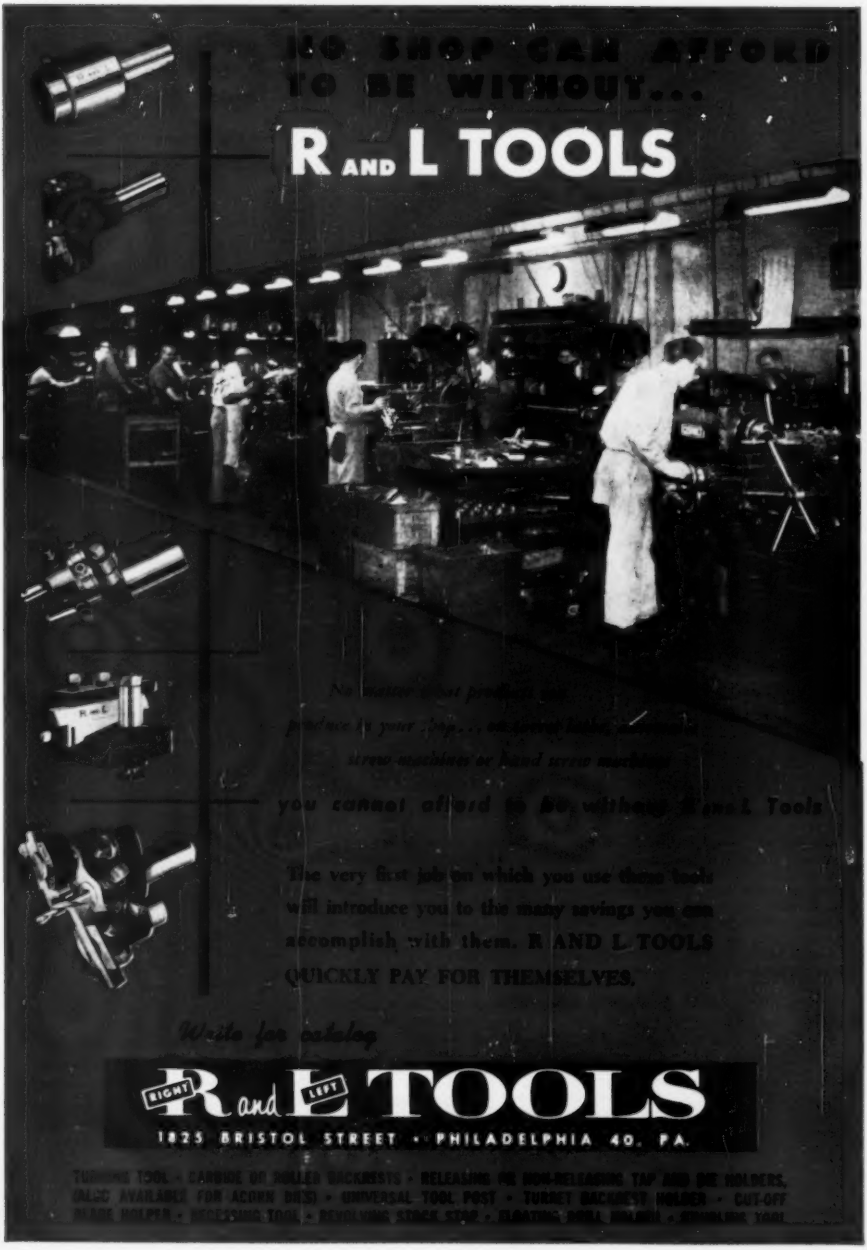
Spot grinding! Smoothing welds! Grinding in corners! Working with odd shapes! Wherever low-cost, fast-operating efficiency is essential, Simonds portable wheels fill the bill. They cut fast, hold their shapes, give long service, and include everything you need—straight wheels, cup wheels, cones, pot-balls and blind-end wheels. Resinoid bonded for high speeds up to 9500 r.p.m. Write for free folder ESA-62.

Rotor type cup wheel—cross section shows steel bushing flange and safety ring.

SIMONDS
ABRASIVE CO.
PHILADELPHIA 37, PA.

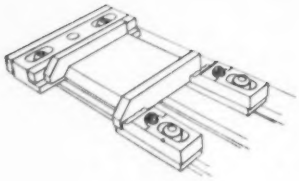
BRANCH WAREHOUSES: BOSTON, DETROIT, CHICAGO, PORTLAND, SAN FRANCISCO · DISTRIBUTORS IN PRINCIPAL CITIES

DIVISION OF KIMBALL SAW AND STEEL CO., LIMITED, TORONTO, ONT. · A UNITED KINGDOM SUBSIDIARY, SIMONDS STEEL MILLS, SHEFFIELD, ENG.
SIMONDS SAWMILL SAW CO., LTD., MONTREAL, QUEBEC AND SIMONDS CANADA ABRASIVE CO., LTD., ARVIDA, QUEBEC


NO SHOP CAN AFFORD
TO BE WITHOUT...
R AND L TOOLS
you cannot afford to be without R and L Tools
The very first job on which you use these tools
will introduce you to the many savings you can
accomplish with them. R AND L TOOLS
QUICKLY PAY FOR THEMSELVES.
Write for catalog
RIGHT R and L LEFT TOOLS
1825 BRISTOL STREET • PHILADELPHIA 40, PA.

J & S DOUBLE ½ VISE
WITH MATCHING PARALLELS

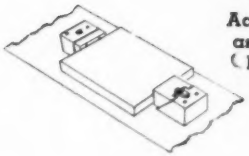
- for unquestionable repeated accuracy
- for quicker set-ups
- for stronger grip
- for less obstruction



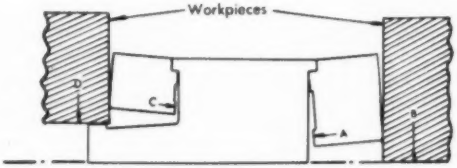
DOUBLE ½ VISE IN USE WITH ALL-PURPOSE JAW CLAMPS

for use on jig borers, millers, planers and shapers.

J & S DOWN-HOLDING COUNTER CLAMPS



Acts on same principle as double ½ vise (left.) Fixture clamps operate on the same principle as the all purpose jaw clamps.

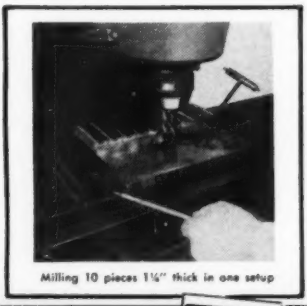


Approximately 3 tons pressure closes Gap A, and approximately ½-ton closes Gap C—producing a down-holding action on each respective piece of approximately the same force.

Hinged, Spring-Loaded Jaw Gives Positive Down-Holding Action

Hinged lip in-and-down action combined with in-and-down action of clamp holds workpiece against table and absolutely parallel. **Construction is of oil-hardened tool steel, ground and blackened.**
Jig Borers—quickly set up for jig boring accuracy.
Millers—eliminates heavy miller vise and allows milling of more pieces.
Planers—eliminates strap and finger setups.
Shapers—eliminates vises.

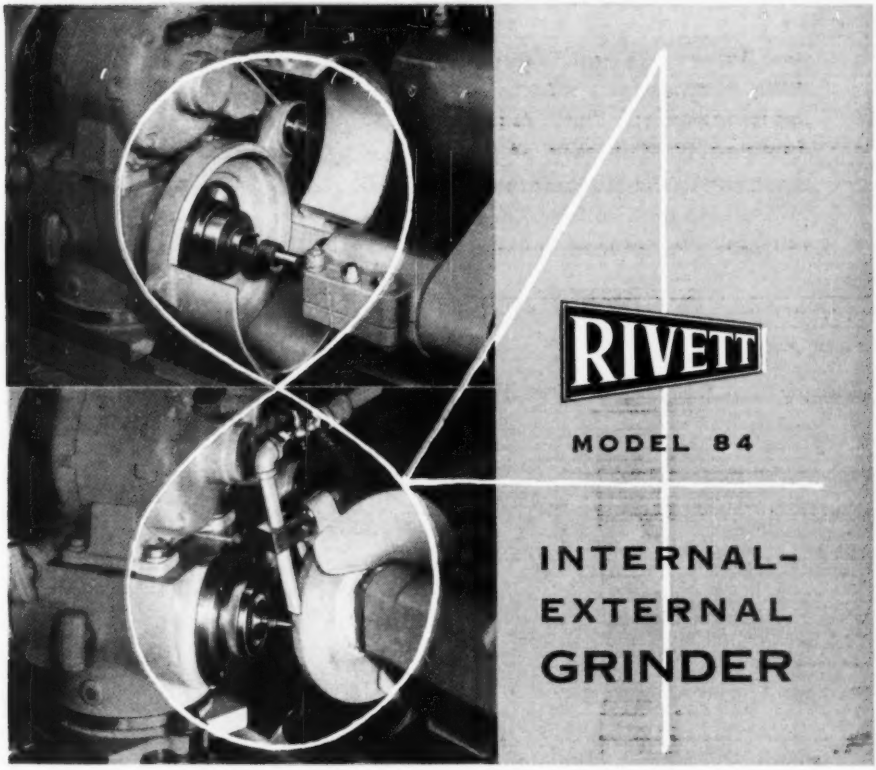
J & S TOOL CO., INC.
647 W. Mt. Pleasant Ave. Livingston, N. J.
(N. J. Highway Route No. 10)

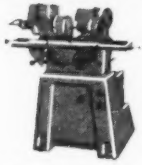


Milling 10 pieces 1¼" thick in one setup

J&S TOOL CO. INC.

DELIVERY FROM STOCK
WRITE FOR NEW FOLDER!
—contains complete details on advantages, applications, types and sizes available.
Booklet describing J & S "Fluidmation" Wheel Dressers, etc., also sent on request.





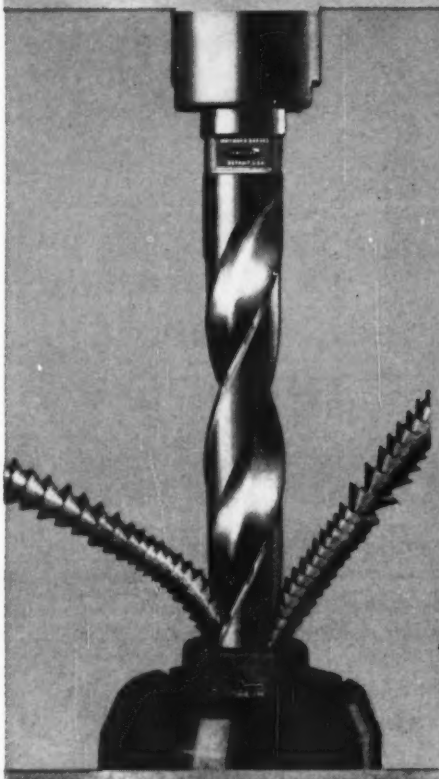
This small hole grinder mounts interchangeable wheelheads for internal and external spindles. Hole capacity is 3" dia. with a maximum depth of 4"; external is to 3" dia. by a 4" length. Collets and step chucks mount directly in lathe-type spindle.

This flexibility combined with the inherent accuracy is why the Rivett 84 has gained great popularity in toolrooms since its introduction to the trade twelve months ago.

Quick and easy to set up, the 84 will handle your diversified jobs faster, too. All the details to prove this are shown in Catalog No. 84-A. **Write for a copy today!**

RIVETT LATHE & GRINDER, INC., DEPT. MTR 1 BRIGHTON 35, BOSTON, MASS.

THINGS TO COME — Future Whitman and Barnes ads will feature examples of cutting tools such as drills, reamers, carbide tools, etc., in actual usage in major industrial plants. Thus you will be able to see how others, by applying W&B quality of tool design and manufacture, have successfully solved their tooling problems, increased production, secured longer tool life, obtained greater accuracy of cutting and substantially reduced tooling costs.



Shown below are but a few of the many quality high speed drills to be found in the complete W&B line.

Hercules High Speed
Straight Shank Taper Length Drill

Hercules High Speed
Straight Shank Taper Length Drill
(Heavy Duty—Extra Length Flutes)

Hercules High Speed
Straight Shank Jobbers' Drill

Hercules Fastwist
High Speed Straight Shank Drill

Contact your W&B distributor

Drills • Reamers • Counterbores
Countersinks • Carbide Tools
Tool Bits • Special Tools

Makers of fine Tools Since 1848

WHITMAN & BARNES

40045 Plymouth Road • Plymouth, Michigan

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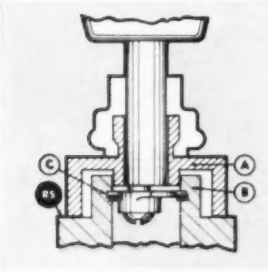
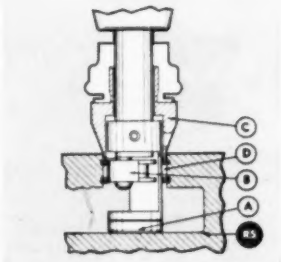
Waldes Truarc Grooving Tool Out-Performs Conventional Recessing Tools

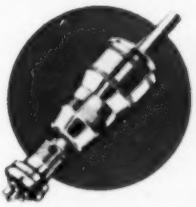
SAVES TIME! CUTS COSTS! NEEDS NO SKILLED LABOR!



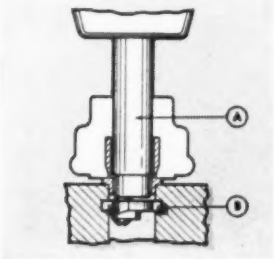
Clearing Obstructions or Protrusions – Waldes Truarc Grooving Tool with *special bushing* with high shoulder A in order to clear obstruction B on reference surface RS so groove can be properly located in bore.



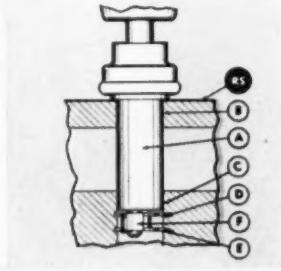
Locating Grooves from Bottom of Hole or Blind Hole – Use of *bottom adaptor* A and double cutter B. Bushing C pilots tool into bore D while bottom adaptor acts as stop to locate grooves from reference surfaces Rs below bore.



AMAZINGLY VERSATILE! The Waldes Truarc Grooving Tool adapts quickly and simply to your toughest recessing requirements. With it, even *unskilled labor* can perform high precision, mass production operations.



Small Diameter Bore – Need for Wide Groove – Great versatility of tools allows A-2 Tool to accept *stepped down spindle* and *cuttershaft* assembly A. Provides cutting capacity in a bore normally within the range of smaller A-1 Tool. Illustrated, larger tool capacity necessary to cut groove diameter B exceeding normal capacity of standard A-1 Tool.

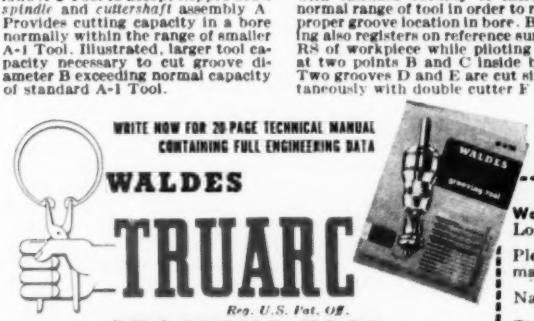


Extending Reach of Tool – Waldes Truarc Grooving Tool assembled with *extended bushing* A increases normal range of tool in order to reach proper groove location in bore. Bushing also registers on reference surface RS of workpiece while piloting tool at two points B and C inside bore. Two grooves D and E are cut simultaneously with double cutter F.

WIDE CUTTING RANGE! The Waldes Truarc Grooving Tool comes in five models: A-1, A-2, A-3, B and C. This wide variety of models enables you to cut accurate grooves in housings with diameters from .250 to 5.000 inches. Special features, modifications and adaptations allow each model to operate efficiently under many varying conditions.

SEND YOUR PROBLEM TO WALDES! Whatever your internal grooving problem, send us your blueprints and let Waldes Truarc engineers give you a complete analysis, price quotation and delivery information on the most economical tool set-up for your particular job.

WRITE NOW FOR 20 PAGE TECHNICAL MANUAL CONTAINING FULL ENGINEERING DATA



WALDES

TRUARC

Reg. U.S. Pat. Off.

GROOVING TOOL

MADE BY THE MANUFACTURERS OF WALDES TRUARC RETAINING RINGS

WALDES KOHINOOR, INC., 47-16 Austel Pl., L.I.C. 1, N.Y.
Waldes Truarc Grooving Tool mfd. under U.S. Pat. 2,411,426

MT-016

Waldes Kohinoor, Inc., 47-16 Austel Place
Long Island City 1, New York

Please send me your new 20-page technical manual on the Waldes Truarc Grooving Tool.

Name _____

Title _____

Company _____

Business Address _____

City _____ Zone _____ State _____

MORTON OFFERINGS FOR JET ENGINE PROGRAMS

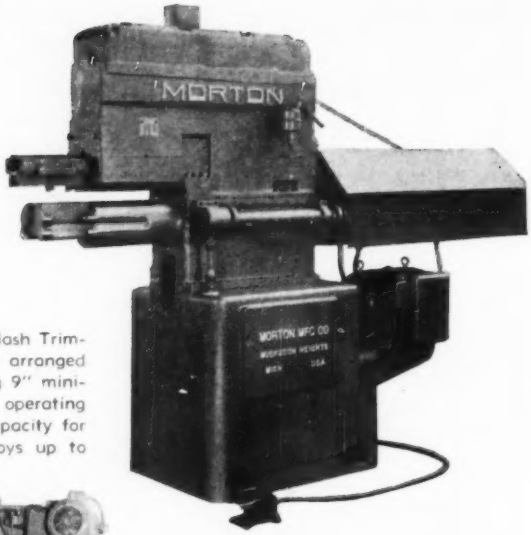


Fig. 2930, Bulletin No. 35-P
Morton 16" Stroke Heavy Duty Flash Trimmer, Hydraulically Driven. It is arranged for flat and circular work having 9" minimum lower horn. It has 2" of operating distance between the dies and capacity for removal of flash of various alloys up to ¼" thick.

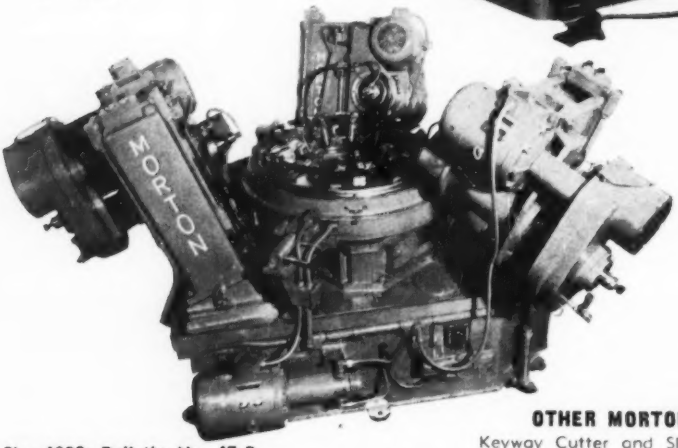


Fig. 4082, Bulletin No. 47-P
Special Three Head Index Milling Machine for milling the pads and bosses on combustion chamber of jet engines. This machine consists of a suitable mounting base with a rotary indexing table onto which is applied three Special Angular Base Unit Milling Heads. The entire machine is hydraulically operated and is actuated electrically to accomplish full automatic cycle. Each milling head has independent motor and control drive for milling 20 pads.

OTHER MORTON PRODUCTS

Keyway Cutter and Slotting Machines — Portable Keyway Cutters and Planers and Milling Machines — High Duty Draw-Cut Production Shapers — Flash Trimming Machines — Horizontal Boring, Drilling, Milling Machine and Draw-Cut Traveling Head Planers — Automatic Welding Machines for Submerged and Inert Arc — Special Jigs and Fixtures — Finished Machine Keys including Hi-Pro and Woodruff.

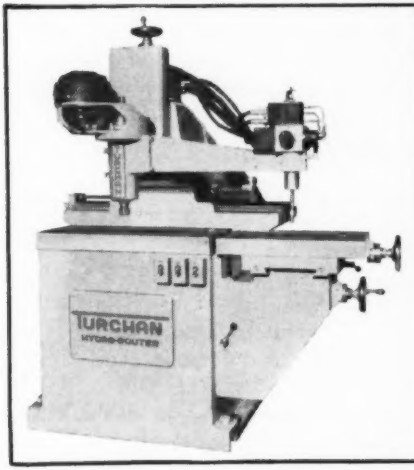
WE INVITE YOUR INQUIRIES

MORTON MANUFACTURING COMPANY
DEPT. P, MUSKEGON HEIGHTS, MICHIGAN

Produce better work, faster, with

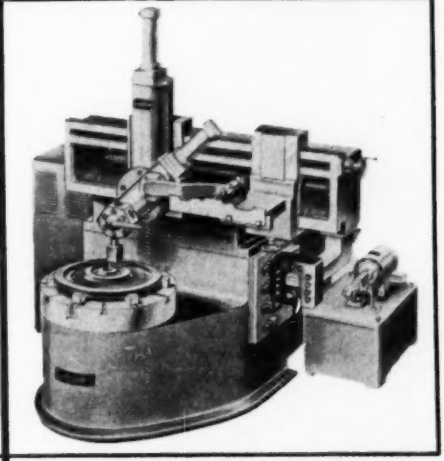
TRACER-CONTROLLED MACHINE TOOLS

New Models 1-24, 2-24 HYDRO-ROUTER



Greater sensitivity, accuracy, and increased duplicating speed result in hours of costly time saved on irregular forms and parts. Infinitely variable 3-dimensional tracer control of vertical, cross, and longitudinal spindle movements produces a superior finish at extreme accuracy of duplication.

New Vertical CONTOUR LATHE



This machine with its many self-governed automatic features is truly an important addition to the growing list of "automatic" machine tools. Built with control features such that loading, unloading, and push-button starting are practically all that is required for fast and accurate reproduction of turned contour parts.

The Complete "Turchan Story" is in Sweet's '54 File

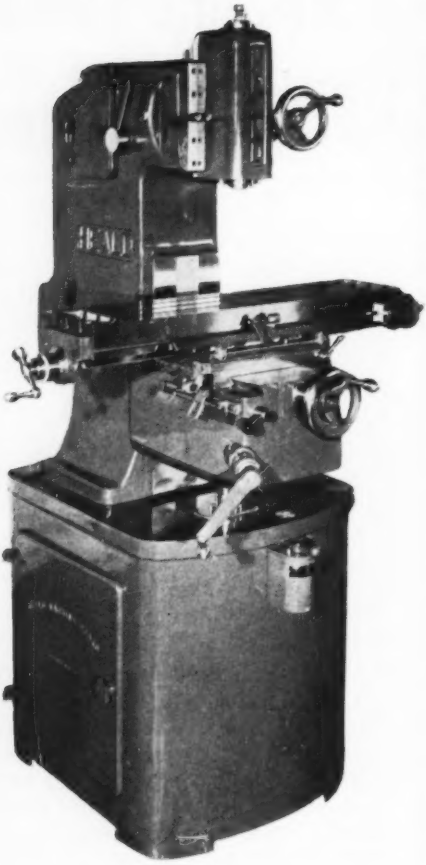
This new, 24-page catalog describing Turchan products and services may be seen in Sweet's File, or write Turchan for your individual copy.

Turchan FOLLOWER MACHINE CO.

Machine Tools Division, 8259 Livernois Avenue, Detroit 4, Michigan

For 20 years, designers and builders of automatic hydraulic tracer-controlled equipment for standard machine tools and special machines

HEALD — MILLING MACHINE



No. 1-V Heavy Duty Vertical Back Geared

Here is a PRECISION BUILT milling machine designed to meet requirements of heavier, higher priced equipment. Listed below are some of the many features which make the Heald Milling Machine, the preferred equipment in many plants.

SPECIFICATIONS

Table size: 7⅝"x34"
Table travel: 22"
Traverse feed: 7"
Vertical travel of the knee: 14½"
Quill travel: 3"
Hand rapid traverse
Longitudinal automatic feed
Vertical head swivels 180°
Spindle speeds: 85 to 3000 RPM
Taper - standard MM 30
2 HP motor recommended
Optional equipment:
- Coolant tank, pump and piping
- Vernier scales
- Optical scales

Write now for pictorial folder complete with specifications. Your copy is free.

Dealer's inquiries solicited, some territories open.

MANUFACTURER'S REPRESENTATIVES

GENERAL MACHINERY & EQUIPMENT COMPANY

2441 EAST KING STREET **P.O. BOX 3128** **TULSA, OKLAHOMA**

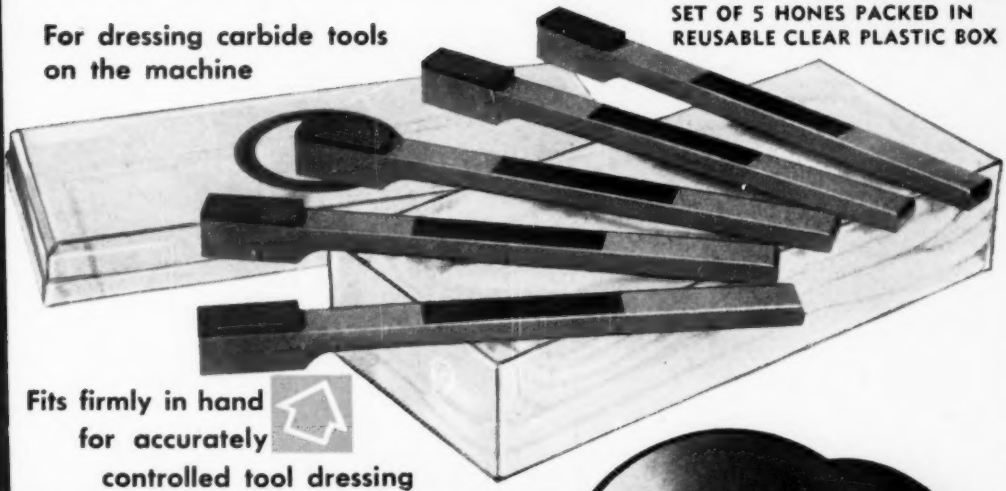
20% LONGER TOOL LIFE BETWEEN REGRINDS

Diamond hand hones

with "finger-tip" control

For dressing carbide tools on the machine

SET OF 5 HONES PACKED IN REUSABLE CLEAR PLASTIC BOX



Fits firmly in hand for accurately controlled tool dressing

for all general shop requirements

SINGLE END.....

SET #1010 5 Hones, Assorted Grits $73.50 per set

complete range for all tool cutter finishing

DOUBLE END.....

SET #2010 5 Hones, Assorted Grits $130.85 per set

SPECIALISTS IN RESINOID AND METAL BONDED DIAMOND WHEELS . . .

United States Diamond Wheels are famous throughout industry . . . they are the world's finest wheels for production tool maintenance. Extra-long, high performance. Rapid stock removal. Perfect "spark-out" on large diameter cutters.

Send for catalog showing complete line of products . . . . . .

UNITED STATES DIAMOND WHEEL CO. AURORA, ILLINOIS

ALCO TOOLS

...SET UP... *Faster*

ALCO RELEASING TAP HOLDER

Cuts perfect threads with no tap breakage with even wear on all threads of the tap.

ALCO TAP HOLDER (Non-releasing)

A spring in the shank moves holder forward when driving, and recedes it when spindle is reversed.

ALCO DRILL CHUCK

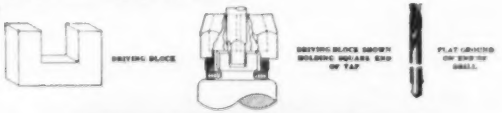
Holds drills, reamers, centers, spotters, counterbores, countersinks, etc. without use of bushings.

Taps and Drills are held rigidly without the use of bushings. Alignment feature of the holders insures concentric drilling and tapping, producing better work faster.

SEND FOR LATEST COMPLETE CATALOG

THE ALCO TOOL COMPANY

ALCO DRIVING BLOCKS On tough materials, or when using excessive feeds, use these Alco Driving Blocks which fit into the drill chuck or tap holder. Slippage is impossible.



ALCO TOOLS

52 BIRDSEYE STREET, BRIDGEPORT, CONN.

The fable of

The Three Brothers

HOLDS A LESSON FOR CUTTING FLUID USERS

The Fable

THREE brothers inherited equal shares of their father's farm. One brother feverishly worked his land, with seldom a rest, until prematurely worn out, he died at an early age. The second brother loafed and played until his land went to ruin and he died for want of food. The third brother, wiser than the other two, *balanced* his work and play, so that he prospered mightily and lived to a ripe old age.

The Lesson

BALANCING the *chemical activity* of cutting fluids produces best results, too.

Figure 1 shows abnormal front clearance wear of a single point tool due to *excessive* chemical activity of the cutting fluid used. The tool failed prematurely, just like the first brother in the fable.

Figure 2 shows abnormal cratering of a tool due to *insufficient* chemical activity of the cutting fluid used. Such cratering is usually associated with poor surface finish. This tool failed prematurely like the indolent brother in the fable.

The *proper balance of chemical activity* gives the most profitable results. For the right cutting fluids for your work, ask to have your Stuart Oil Representative call, or write:

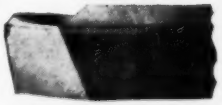


FIG. 1 — Abnormal front clearance wear caused by *excessive chemical activity* of cutting fluid.

FIG. 2 — Cratering of cutting tool, usually associated with poor finish, resulting from *insufficient chemical activity* of cutting fluid used.

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BRAND NEW...FOR FAST, SAFE

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Remove flash from castings...*fast, safely!*

continually putting **more sense** in your **abrasive dollar**...

Finish rough edges... *fast, safely!*

Cut off or slot... *fast, safely!*

ROUGH GRINDING AT LOW COST

Roughing? Grinding Welds? Cutting off? Slotting?—here's a great new cost-cutter by CARBORUNDUM to help you do a fast, safe job. CARBOFLEX Depressed Center Wheels are strongly reinforced for complete operator safety, yet give you an *extra-high rate of cut.*

Here are some typical jobs where CARBOFLEX Depressed Center Wheels have proved their superiority: under-cutting and reducing heavy welds, cleaning castings, roughing off fins and sharp edges, notching and cutting off gates and risers, removing surface defects, and general purpose roughing, slotting and cutting off.

An exclusive feature of the CARBOFLEX Depressed Center Wheel: the back, as well as the face, is knurled. You can cut with either side plus the edge, without initial dressing.

The right combination of tough, top-quality abrasive grain and a strong, reinforced bond is what makes CARBOFLEX Wheels so effective. Tough, durable CARBOFLEX Depressed Center Wheels combine extreme high strength and resistance to cracking with maximum cutting ability... the only combination that gives you more production per wheel at less abrasive cost.

Use CARBOFLEX Depressed Center Wheels on your toughest jobs. You'll be more than pleased with the results!

● **OUR DISTRIBUTOR OR SALESMAN** is ready to demonstrate this new cost-cutter. He's listed in the yellow pages of your telephone directory—under "Abrasives" or "Grinding Wheels." Call him... or, if you prefer, write to The Carborundum Company, Dept. BB 81-41, Niagara Falls, N. Y.

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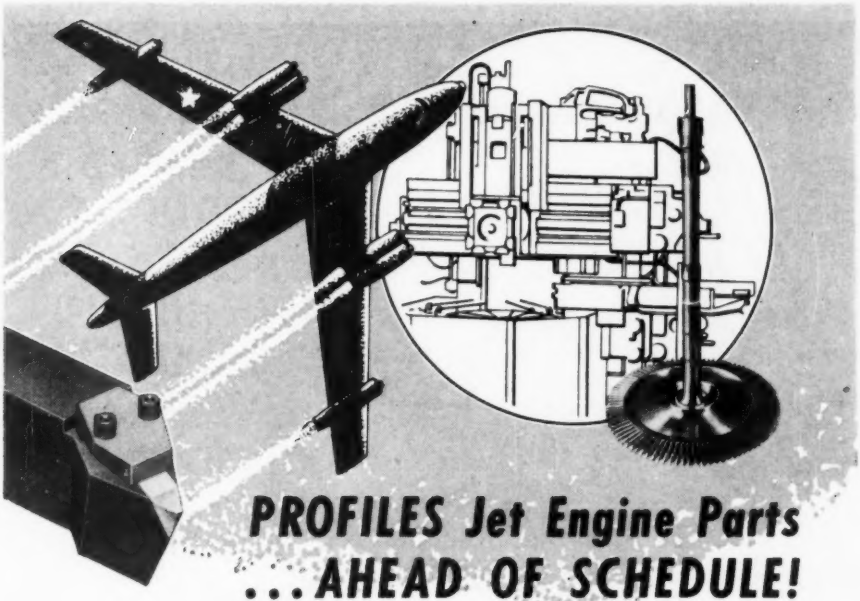

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Profiling is the modern method of machining intricate contours on metal parts, using a cutting tool which is electronically guided by a stylus following a template. It has these cost-saving advantages:

Piece after piece can be accurately produced, each an exact duplicate of the other—at much higher production rates, using far less skilled operators' time—*IF* . . .

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This is typical of Kennametal's leadership in adapting tungsten carbide to the specific needs of industry. Whether it be a tool for cutting tough metals or the need for a high shock, abrasion or wear-resistant material for vital parts in your products or processing line, Kennametal may be the answer. It is 100 times as resistant to wear as steel . . . almost as hard as the diamond.

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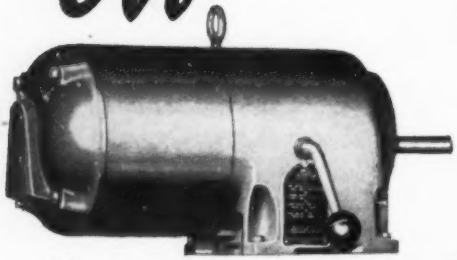

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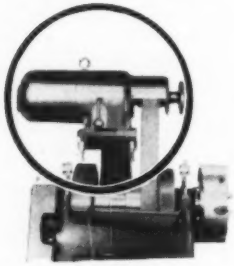

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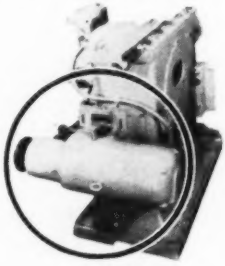

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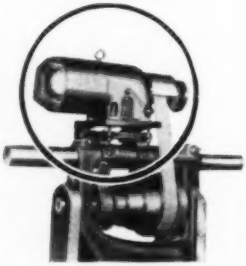

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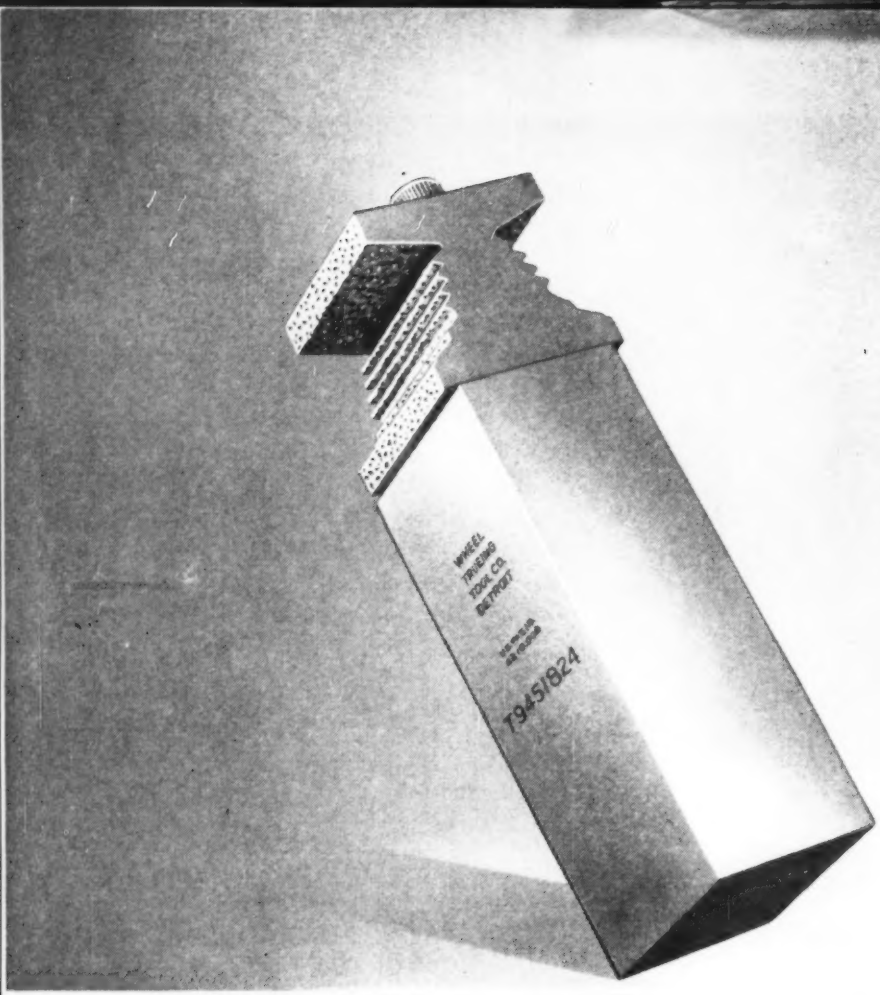

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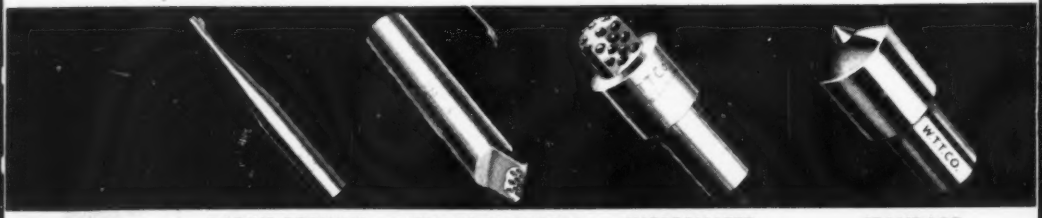

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drastically cut wheel-forming costs.

The Diamond Grit Form-Block is the result of a project started by our engineers three years ago aimed at reducing time and cost factors in rough forming opposed abrasive wheels used simultaneously in grinding turbine jet "buckets".

The rough forming operation had been taking ten to fifteen hours and, because it was performed on the grinding machine, downtime was very costly.

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The Diamond Form-Block has long life. One Form-Block has formed 30 pairs of 20" wheels without showing appreciable wear.

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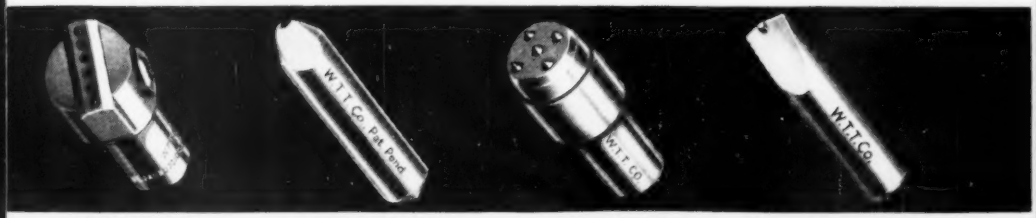

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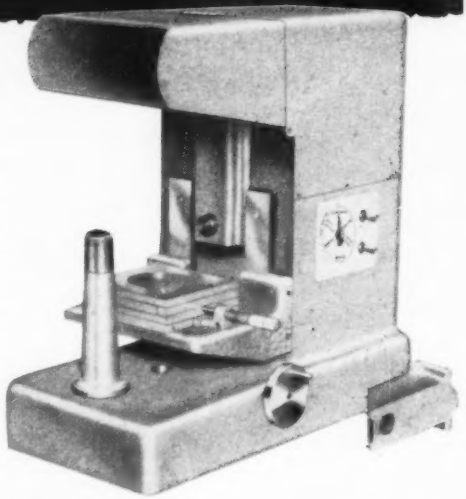

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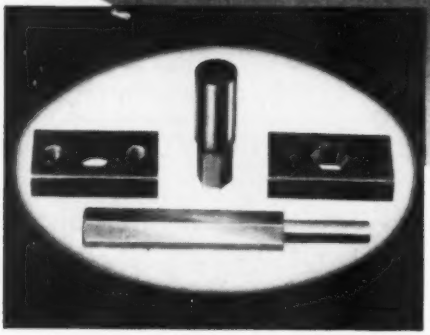

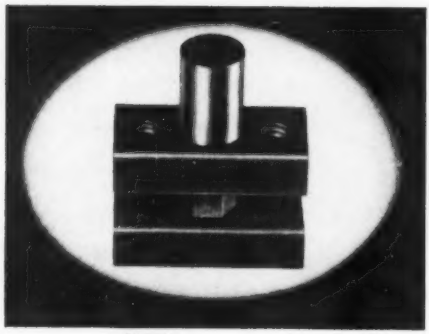

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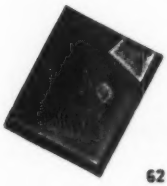

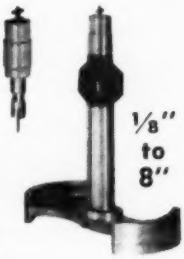

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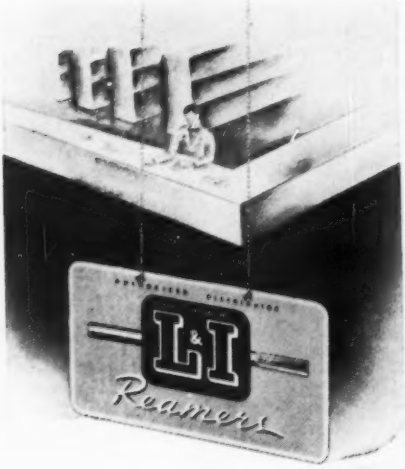

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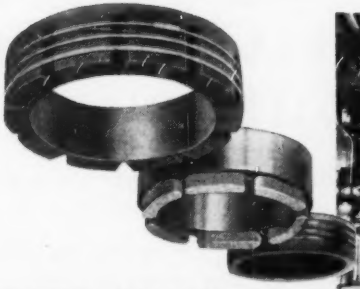

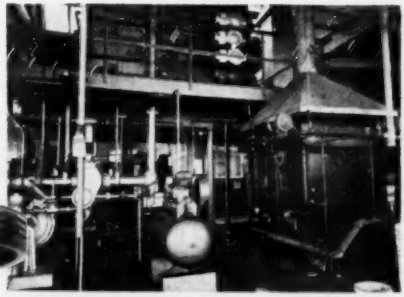

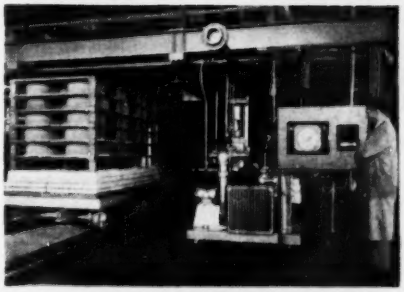

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The collector element is mounted on the side of the machine. Quickly cleaned, requiring no refills.

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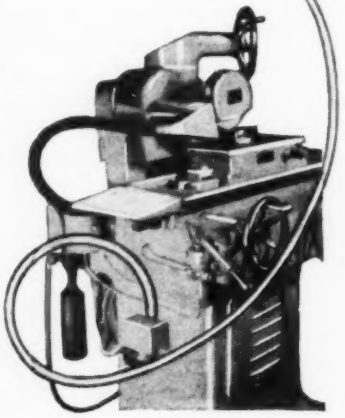

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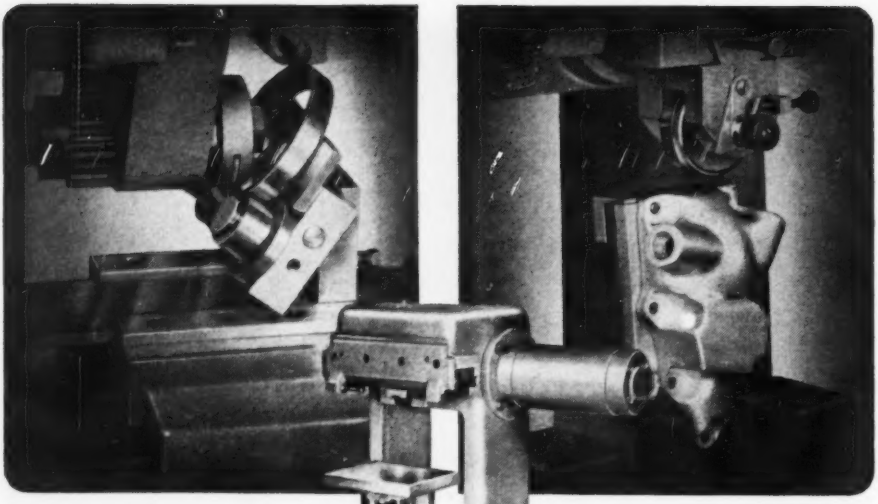


Above left—Tooled for marking part numbers on the I.D. of steel rings—component parts for aircraft engines.

Above right—Tooled for marking aircraft engine rocker box covers.

ROLL-O-MARK'S Versatility

All-pneumatic Model 50P1

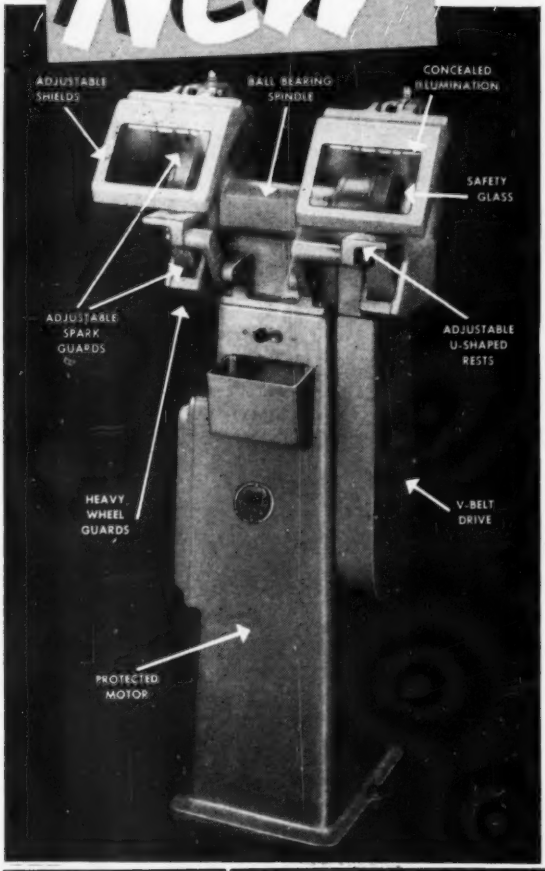
for precision metal marking at lower production costs.

It will pay you, as it has hundreds of other manufacturers, to put your marking problems up to Noble & Westbrook Mfg. Co., 9 Westbrook Street, East Hartford 8, Conn. Complete catalog sent upon request.

MARK IT BEST WITH NOBLEWEST IMPROVED MARKING DEVICES

NOBLEWEST

New



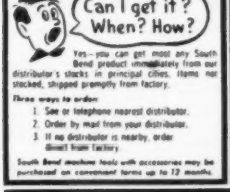
SOUTH BEND
PEDESTAL
GRINDER

A ruggedly built grinder that will give long, dependable service under hard use. Ideal for rough or precision grinding. The motor is enclosed in the pedestal and drives through a V-belt. This removes the weight of the grinding wheels from the motor bearings and practically eliminates vibration. Moreover, it isolates the motor from abrasive dust and provides greater work clearance. Send coupon for complete information on this better-built grinder.

SPECIFICATIONS

Wheel Size: 8" dia. (½ h.p. motor), 10" dia. (¾ h.p. motor).
Spindle: Approx. speed 2450 r.p.m. Sealed ball bearings.
Motor: Standard 2875 r.p.m. 50 cycle or 3450 r.p.m. 60 cycle. Also D.C.
Over-all Dimensions: 49½" high, 18" wide, 20½" deep (10" Grinder ½" wider).

8"—$245.00; 10"—$248.00 each less motor and remote control equipment. Terms are 10% down—balance in 12 months.
F.O.B. Factory



Yes—you can get most any South Bend product immediately from our distributor's stocks in principal cities. Items not stocked, shipped promptly from factory.

Three ways to order:
1. See or telephone nearest distributor.
2. Order by mail from your distributor.
3. If no distributor is nearby, order direct from factory.

South Bend machine tools with accessories may be purchased on convenient terms up to 12 months.

SEND INFORMATION CHECKED:

☐ 9" and 10" BENCH LATHES

☐ 10" to 16-24" FLOOR LATHES

☐ DRILL PRESSES

☐ TOOL GRINDERS

☐ ½" & 1" Collet TURRET LATHES

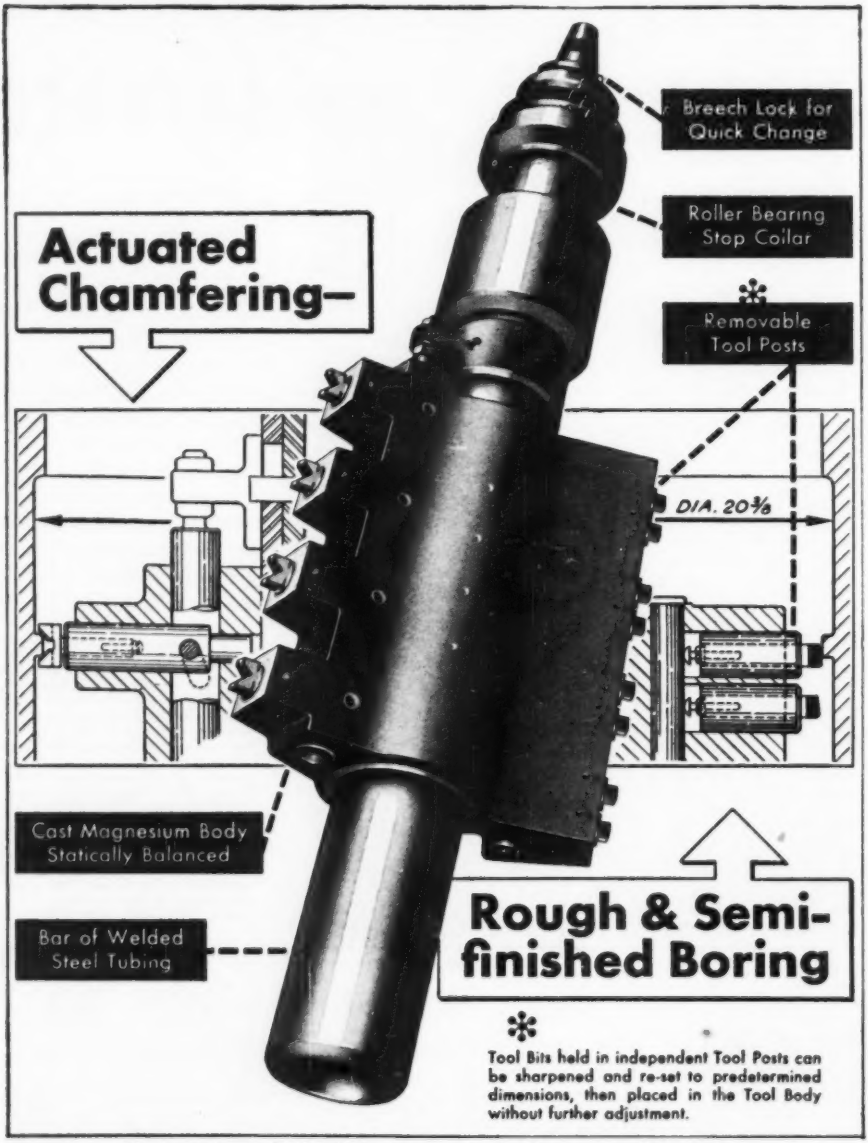
☐ 7" BENCH SHAPERS

Name _____ Company _____

Street _____ City & State _____

Building Better Tools Since 1906 • **SOUTH BEND LATHE** • South Bend 22, Indiana

TOOLING *by* GAIRING

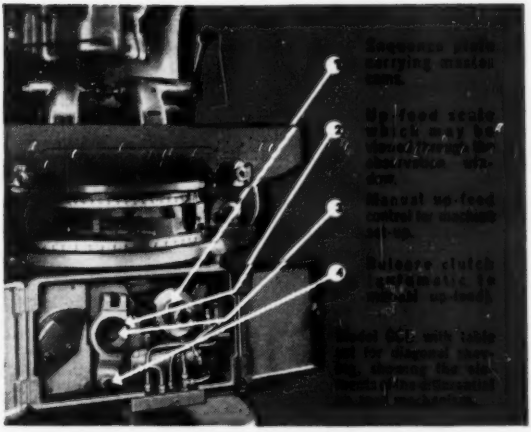


✻ Tool Bits held in independent Tool Posts can be sharpened and re-set to predetermined dimensions, then placed in the Tool Body without further adjustment.

In Canada: A. C. Wickman (Canada) Ltd., Queensway, Toronto 14

The GAIRING TOOL COMPANY • 21228 Hoover Road • Detroit 32, Mich.

GEAR SHAVING NOW *Much Faster and More Flexible*

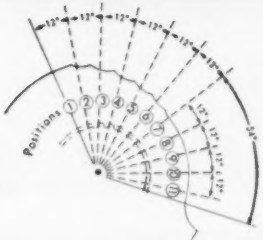


When Automatic Differential Up-feed and Conventional Crowning were added to the Red Ring Model GCU, shaving speed, flexibility and economy were all significantly increased.

AUTOMATIC DIFFERENTIAL UP-FEED

This efficient device provides for the first time an automatic cycle applicable to both diagonal and conventional shaving. This cycle is controlled by an eleven-position master cam. Included are backlash take-up, infeed cutting strokes, idling strokes and return to unloading backlash. The entire cycle or any portion of it may be used depending on job requirements.

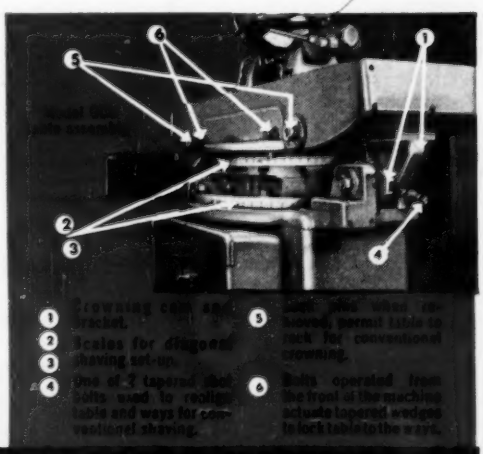
The cam itself does not actuate knee movement. It is strictly a stepped gaging device. Consequently every knee movement is positive, extremely precise and very fast. No danger of operator's errors. Perfect accessibility for fast loading and unloading.



One of the two control cams carried by the feed unit sequence plate.

CROWNING

Gears being shaved conventionally can be crowned by rocking the table about a central pivot during the automatic cycle. The cam controlling the rocking movement is located on table centerline to avoid any tendency to twist. This device also provides for taper shaving.



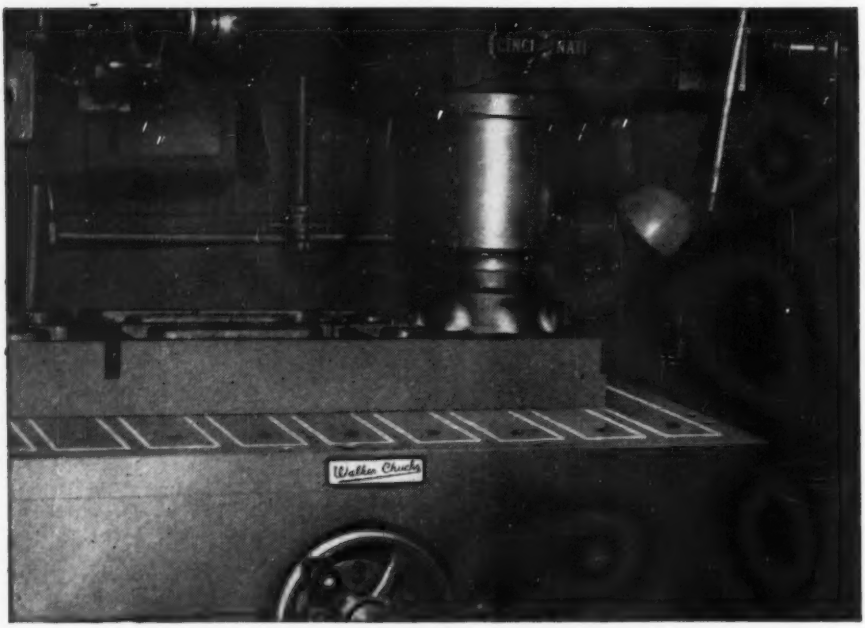
Write for Bulletin S53-7 for full details.

NATIONAL BROACH & MACHINE CO.

5600 ST. JEAN . . . . . DETROIT 13, MICHIGAN

6612

WORLD'S LARGEST PRODUCER OF GEAR SHAVING EQUIPMENT



Milling machine operating carbide cutter 660 f.p.m.; table feed 25 i.p.m.; on rough steel castings. Walker Magnetic Chuck, securely holding workpiece, increases production equivalent to work of four planers.

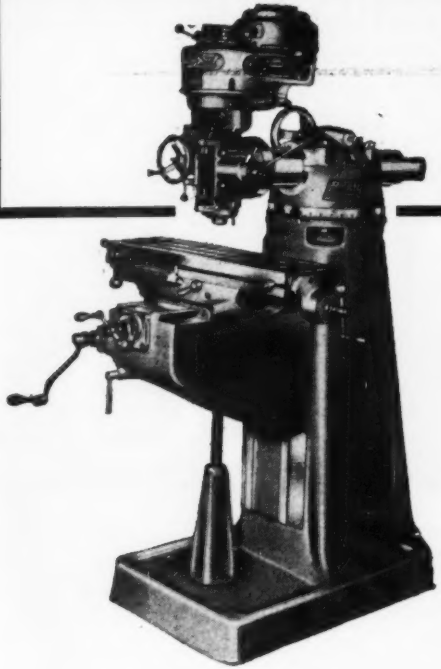
AUXILIARY PLATES—For complicated holding problems involving odd shapes and contours, Walker engineers utilize basic principles of the magnetic chuck, either electric or permanent type. Walker auxiliary plates will give you maximum magneto motive force transmission to the workpiece.

In Canada — Upton Bradeen & James, Ltd.

O. S. WALKER CO. Inc.

WORCESTER 6, MASSACHUSETTS

Original Designers and Builders of Magnetic Chucks



The Only Way to Meet 1954 production needs is on 1954 MACHINES . . .

Bridgeport

TURRET MILLING MACHINES provide for all TODAY'S REQUIREMENTS

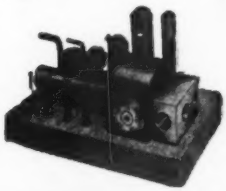
Production problems of all kinds are being met and solved through the speed, low cost, accuracy and convenience of "BRIDGEPORTS". These machines offer the exclusive feature of being able to mill, drill, bore and shape, combined with ability to position the milling head at all angles over a wide area, **without changing set up.**

The year just passed has seen more than 2500 Bridgeport Milling Machines shipped to shops which are interested in making worthwhile improvements in their production and which appreciate the value of modernization made possible through the use of machines which are in many respects away ahead of their time in performance and end results . . . machines that are not only "1954 machine tools" but which will still be modern for many years to come.

Milling Machine Vise

This improved vise provides greater gripping power, is streamlined for appearance, has a large diameter screw for rigid holding and a coolant trough. Made in two sizes" 5"x3½" and 6"x5" jaw openings.

Ask your dealer . . . or us . . . to show you how you can make the "BRIDGEPORT" a worthwhile investment for 1954 and for years ahead.



Boring Head

No. 2 Boring Head Boring Tools and Holder provide the means for boring holes up to 6" diameter. Available for use on Bridgeport 1 HP Milling, Drilling and Boring Attachment.

RIGHT ANGLE ATTACHMENTS

Left: Heavy Duty . . . for milling and drilling at right angles. Available for both Master and 1 HP Bridgeport Heads.

Right: Light Duty . . . for right angle milling and drilling narrow, deep molds and cavities.

Bridgeport MACHINES, INC.

Bridgeport, Connecticut

Manufacturers of High Speed Milling Attachments and Turret Milling Machines

THEY HAVEN'T A FRIEND IN THE WORLD!

AMES

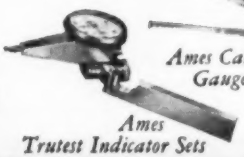
...the preferred

. . . not because they cost more (in the long run they're more economical) but because they're completely impersonal!

Ames Micrometer Dial Gauges and Indicators meet the demand for increasingly critical precision instruments. They are built by exclusive Ames methods and machines, and 100% checked for accuracy. They are extremely sensitive yet ruggedly built to give you *longer* service with *less* down-time.

Ames Long Range Dial Indicator No. 262

Ames Dial Comparator No. 13



Ames Trutest Indicator Sets

Ames Caliper Gauge No. 12B

Ames Dial Micrometer No. 502

Send today for your free copy of Catalog No. 58

Representatives in principal cities. B. C. AMES CO. *28 Ames Street Waltham 54, Mass.*

Mfgr. of Micrometer Dial Gauges • Micrometer Dial Indicators

- Profile of work and grinding wheeledge shown in 20 to 40 times magnification.
- 20 times magnification gives accuracy of .0002 inch, 40 times gives .0001 inch.
- For flat form, relief form, axial circular form or radial circular form grinding.
- Simple, easy, rapid vertical and horizontal adjustment. Two control wheels smoothly guide projection of grinding wheel.
- Solid comfort for operator. Automatic dust removal.
- An experienced form grinder can easily improve upon the degree of accuracy given above.

ALBERT KLINGELHOFER MACHINE TOOL CORP.
INDUSTRIAL PARK • KENILWORTH, NEW JERSEY

ILLUMINATED MAGNIFIER

for inspection and assembly

Operator has both hands free. Complete unit including adjustable stand, with precision wide-field lens designed for use at "normal" working distance from eyes. $13.50. See complete line of industrial magnifiers $1 to $25, stocked by leading industrial suppliers. Bausch & Lomb Optical Co., 51225 Bausch St., Rochester 2, New York.

Write today for tell-all handbook and catalog, "INDUSTRIAL MAGNIFIERS, HOW TO CHOOSE AND USE THEM"

BAUSCH & LOMB

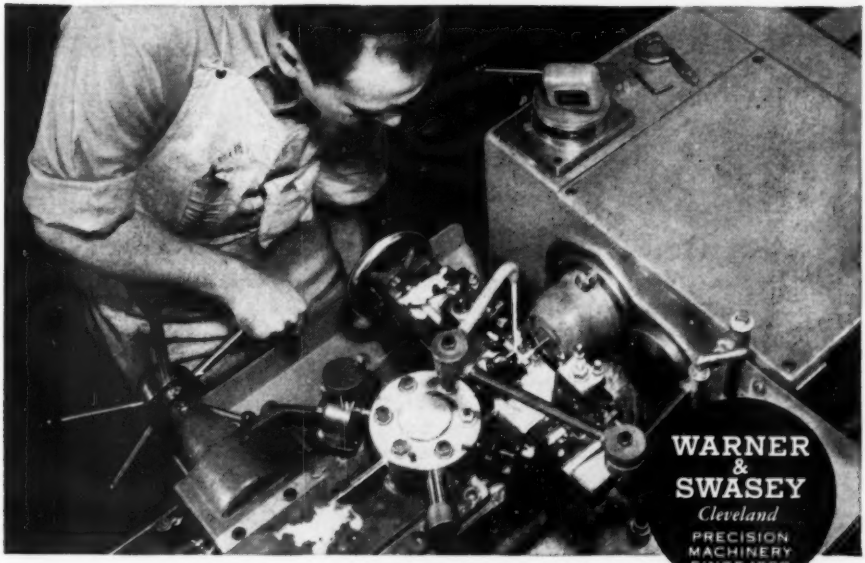
Industrial Magnifiers

NOW! a small capacity turret lathe that turns stainless and alloy steels more accurately than ever before!

Now, for the first time, all the versatility of a larger turret lathe has been incorporated in a No. 1 model—the Warner & Swasey No. 1 Electro-Cycle. It is easy to operate and control, designed to meet the high speed requirements of many small diameter bar jobs—to provide plenty of cutting torque at low speeds even for turning and threading hard steels.

Also for the first time, the new No. 1 E-C gives you power feed to turret, a decided advantage in turning high precision jobs involving stainless or alloy steels. This feature, combined with the 1 E-C's wide range of spindle speeds, enables you to make the most efficient use of tools—providing better, more uniform finishes whether you're turning plastics, brass or hard steels.

And like all Warner & Swasey Machine Tools, the No. 1 E-C is ruggedly built to provide the rigidity necessary for lasting accuracy.



No. 1 Electro-Cycle Turret Lathe—⅝" Bar Capacity

YOU CAN PRODUCE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY MACHINE TOOLS, TEXTILE MACHINERY, CONSTRUCTION MACHINERY

NOTHING
COMPARES
WITH IT FOR
TRIMMING
FORMED
PARTS!

FRICTION
SAWING with

Tannewitz HIGH SPEED
BAND SAWS

Tremendous savings of time and money are effected in trimming formed parts with Tannewitz High Speed Band Saws, for not only are the cuts made fast and smoothly, but in most cases no jigs or rests of any kind are required. Sheets of both soft and hard steel, non-ferrous metals and many other materials are also handled to great advantage by this method and it is perfect for trimming castings. By all means get the complete facts and learn of the many opportunities for boosting production and lowering costs that Friction Sawing with Tannewitz High Speed Band Saws offers.

The TANNEWITZ WORKS GRAND RAPIDS MICHIGAN

WRITE FOR FREE COPY OF FRICTION SAWING

What's different about VIXEN FILES?

Vixen is the original and still the best. These milled curved tooth files cut freer, faster, smoother because:

1. Milled curved teeth are actually miniature milling cutters.
2. Gullets are not pointed but rounded, to make chips fall free easier.
3. Undercut teeth have distinct cutting action, do not scrape or abrade.
4. Special analysis chrome steel keeps teeth sharp longer.
5. Vixens may be resharpened many times.

ASK YOUR HELLER DISTRIBUTOR FOR COMPLETE INFORMATION

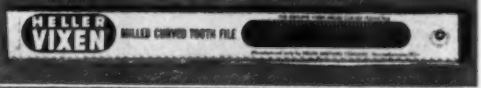
The Milled Curved Teeth of Vixen Files have deep gullets and wide pitch to prevent clogging. This eliminates tracking or serrating and leaves a scratch-free work surface. Made of special analysis chrome steel, Vixen's undercut teeth remain keen longer. Vixens are available in all types of milled curved teeth files—a *complete* line.

THESE FAMOUS FILES ARE MADE ONLY BY

American-Swiss
VIXEN
NUCUT

HELLER BROTHERS CO.
America's Oldest File Manufacturer
NEWCOMERSTOWN, OHIO

IDENTIFY VIXEN BY THE WHITE ENVELOPE



Only HELLER make the Vixen
the original and still the best
Milled Curved Tooth File!

HELLER BROTHERS SINCE 1839

New Thompson AUTOMATIC double wheel TRUFORM Grinder speeds jet engine production

GRINDS BOTH SIDES OF JET TURBINE BUCKETS OR BLADES SIMULTANEOUSLY IN A SINGLE SETTING

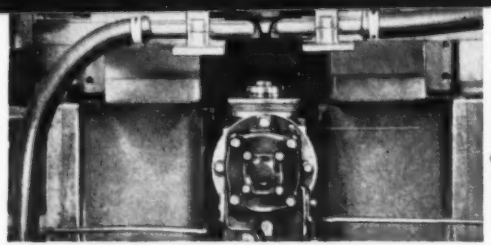
To grind root sections on gas turbine buckets with greatest accuracy and productivity, Thompson developed this new AUTOMATIC double wheel TRUFORMING machine featuring simultaneous grinding of both sides of root section with one setting of work.

Grinds rough to finish in 110 seconds . . . or 30 buckets per hour

Hood doors, work clamps, coolant flow, grinding and crushing cycles are actuated in automatic sequence on the new Thompson AUTOMATIC double wheel TRUFORM Grinder.

On a bucket having 2" length of form similar in design to the one in the diagram above with .150" stock removal per side from rough to finish size, production is 30 buckets per hour at a steady day after day rate. This includes down time for dressing, regrinding the crusher roll, initial machine warm up period, wheel changing and diamond changing. Actual machine time from rough forging or casting to finish is 104 seconds plus 6 seconds for loading and unloading time . . . makes total time floor to floor 110 seconds per piece.

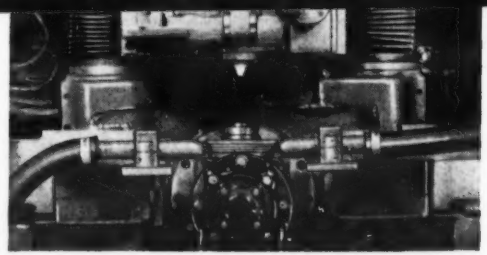
FOR ABSOLUTE SYMMETRY



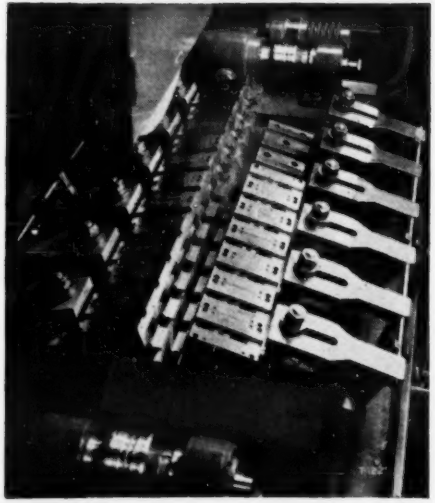
DRESSED FROM A
SINGLE CRUSHER ROLL

GRINDING POSITION

CRUSHING POSITION



Standard THOMPSON TRUFORM Machines also grind jet buckets faster, better

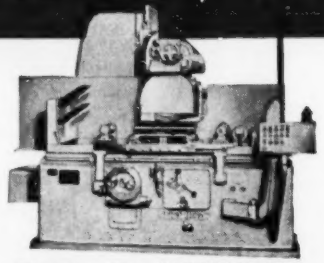


By means of multiple grinding of jet turbine buckets the standard TRUFORM Grinders still offer high production plus many advantages such as flexibility of standard machine design and lower first cost. Although compared to the new AUTOMATIC the standard TRUFORM requires more skillful set up and tooling.

Typical tooling on Type "C" TRUFORM producing 24 buckets per hour. Type "B" TRUFORM produces 18 parts per hour.

FOR COMPLETE DETAILS WRITE TODAY

The Thompson Grinder Co.
Springfield, Ohio

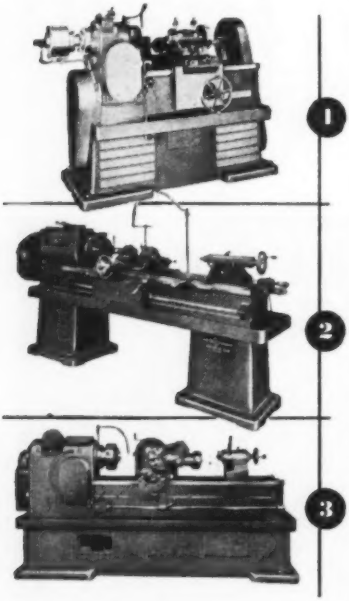


Thompson Type "C" TRUFORM

Thompson
SURFACE
Grinders

If it has to be precision THREADED ...a COULTER will do it faster, more accurately!

With a reliable COULTER Automatic Threading Machine on your line, you will hold your share of today's speed-up-of-production demands! You will thread parts in a greater variety of lengths and diameters with diverse materials to more accurate specifications and far better quality than with any other threading machine built . . . and everything is automatic!



3 models for Varying Threading Operations:

1. **"H1" Hob Thread Milling Machine**
   . . . for precision, internal and external threads . . . AUTOMATICALLY.
2. **"L1" Threading Lathe**
   . . . for precision, square, standard and 29 degree threads . . . AUTOMATICALLY.
3. **"Threadmaster" Thread Milling Machine**
   . . . for precision, long and short traversing, elevating, cross feed and lead screws . . . AUTOMATICALLY.

If you are planning to purchase a threading machine, it will pay you to look into the COULTER line. We welcome opportunities to discuss your threading problems and quote on equipment engineered to your special requirements.

Machine Tool Builders Since 1896

The James Coulter Machine Co.

637 Railroad Ave. Bridgeport 5, Conn.

New PORTLAND HEAVY DUTY MILLING HEAD

Easily Converts Outmoded Planers to Planer Type Mills

This rugged head was originally designed by Portland Machine Tool Works, Inc. for the milling of armor plate, special alloys and other work requiring a heavy duty head. Heads are easily adapted to planers transforming them into modern powerful, efficient planer-type milling machines.

Standard heads are provided with 22 speeds in various ranges up to 1000 r.p.m.

Infinitely variable hydraulic feed from 0" to 60" per minute enables a fine adjustment of cutting rate for maximum efficiency.

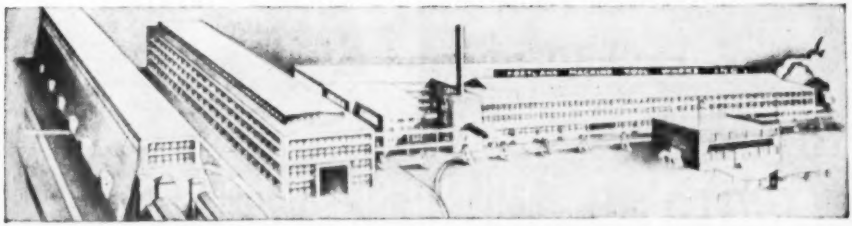
The heads are designed for right and left hand, horizontal and vertical operation. Horsepower ratings are available from 10 to 100.

Other products of the Portland Machine Tool Works, Inc. include: Heavy Duty Vertical Milling Machines; Hydraulic Power-Pac Variable Speed Drive; Special Machinery; Tracer Controlled Milling Equipment.

For further information on our products, designing service, machine tool rebuilding facilities and heavy milling and boring department, write for bulletin BB.

WE BUILD THE BEST—REBUILD THE REST

PORTLAND MACHINE TOOL WORKS, INC.



FOOT OF BROADWAY **SOUTH PORTLAND, MAINE** **Telephone 3-0231**

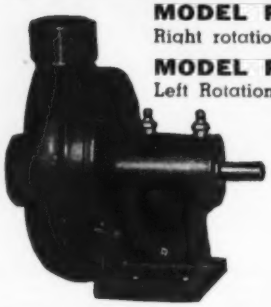
NOT TOO LITTLE... NOT TOO MUCH...BUT JUST ENOUGH COOLANT

FULFLO

CENTRIFUGAL COOLANT PUMPS

MODEL FRS4
Right rotation

MODEL FLS4
Left Rotation



Direct connection:

1800 to 2400 rpm; 35 gal. at 1725 rpm; 20-ft. head; also with pulley for belt drive if desired

1. Be sure you're using the right type of coolant . . .

2. Bring it to the right spot, pumped and circulated by the FULFLO PUMP designed for the purpose. That's good, sound engineering advice on how to KEEP TOOLS COOL AND MAKE THEM LAST LONGER.

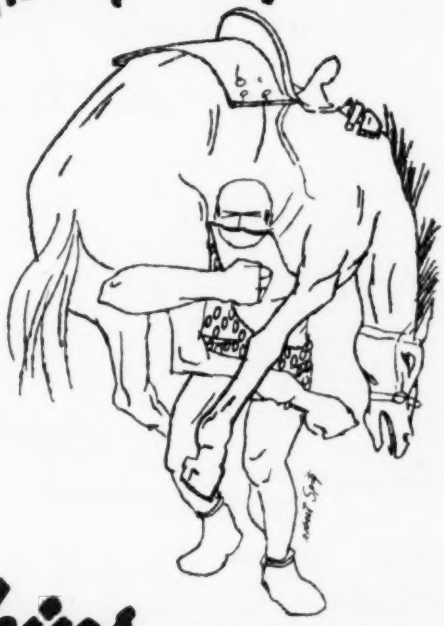
Direct or motor drives: capacities ¼ hp 25 gpm to 1 hp 90 gpm; pipe sizes ⅜" to 1½".
Let the FULFLO engineers help. Write (on your letterhead, please) for your professional copy of

FULFLO MECHANICAL DATA BOOK

FULFLO

THE FULFLO SPECIALTIES CO. Inc.
BLANCHESTER, OHIO

Why carry the horsepower?



USE **haskins** FLEXIBLE SHAFT TOOLS

FOR ALL *grinding · sanding · filing · polishing*

Why burden skilled hands with the chore of manhandling bulky, heavy, conventional grinders? Haskins flexible shaft equipment furnishes all the power required for the job—without the weight. And the Haskins line includes models with horsepowers, speeds, tools and attachments that will exactly suit your job. Write for the latest catalog which describes all models.

HASKINS

R. G. HASKINS COMPANY

2645 W. Harrison Street · Chicago 12, Ill.

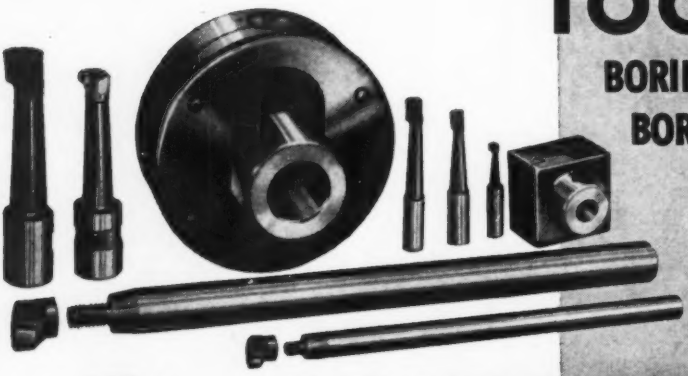
for more *Accurate* cuts...

greater *Rigidity* in

BORING TOOLS

BORING HEADS

BORING BARS



Use CRITERION

BORING EQUIPMENT

BORING PROBLEMS? CLOSE TOLERANCE?

Try Criterion Boring Tools. Built with the same care and quality as the time-tested Criterion Boring Head.

THIS COMBINATION WILL PRODUCE RESULTS.

Boring heads from 1½ to 7 inch diameter. Boring tools carbide or high speed steel, ⅜ to 1¾ inches diameter. Bore holes from ⅛ to 20 inch diameter.

Accuracy for the closest tolerance • Rigidity for the heavy cuts • Heat-treated parts for long wear

LARGE OFFSET SAVES TIME AND TOOL CHANGES

These tools will cut your boring costs.

See the complete line of CRITERION TOOL PRODUCTS at your local dealers or write for free catalog.

CRITERION
MACHINE WORKS

9312 SANTA MONICA BLVD • BEVERLY HILLS, CALIF.

NEW!

THE MODERN TYPE M STUD SETTER*

A Better Stud Setter for Better Stud Setting!

**Details on Request*

MODERN TOOL WORKS

DIVISION

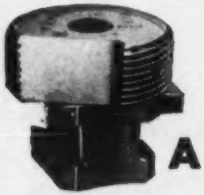
CONSOLIDATED MACHINE TOOL CORPORATION

WHOLLY OWNED SUBSIDIARY OF FARREL-BIRMINGHAM COMPANY, INCORPORATED

ROCHESTER, NEW YORK

VERS-O-TOOL

CHOICE



A

CIRCULAR GROUND THREAD CHASER

ADJUSTABLE BLADE CHASER
HEAD SIZES: 3/8 - 2"

B

THREAD CHASER

It's this simple...you start with a precision built self-opening die head —the Vers-o-tool—then just choose either of two types of chasers least costly for the job.

A If it is a long run job—specify circular ground thread chasers. They give you maximum chaser life by any comparison, regrind to a full 270° circumference. Up to 10,000 threads per grind on screw stock isn't unusual.

B For smaller lot threading—use the Namco Adjustable Blade type chasers, also with ground threads.

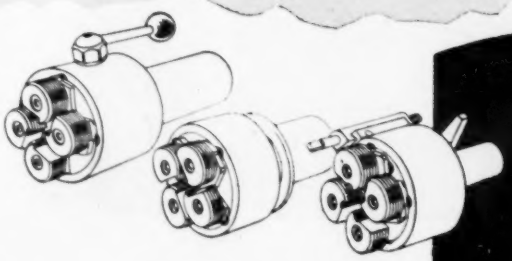
Both styles are interchangeable, head size for head size, between revolving and non-revolving Vers-o-tools.

ONE VERS-O-TOOL and SELECTIVE CHASERS . . .

cuts your threads . . . cuts your tool investment and cuts your operating costs

This system also includes a Namco Micrometer Gage, which checks the chasers—does away with trial cuts after grinds, gives many more pieces per grind, reduces reject losses and saves wasting expensive man-hours. Class 3 threads are guaranteed—and smoother.

Every month, more threading departments join our lists of exclusive Vers-o-tool users. Maybe you'd like to try out this double-duty head. If rising costs are your problem—you should. Send a sample with "specs," large or small run, and we will show you. Ask for Catalog DT-52.



The NATIONAL ACME COMPANY

170 EAST 131st STREET • CLEVELAND 8, OHIO

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1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • Limit, Motor Starter and Control Station Switches • Solenoids • Contract Manufacturing.

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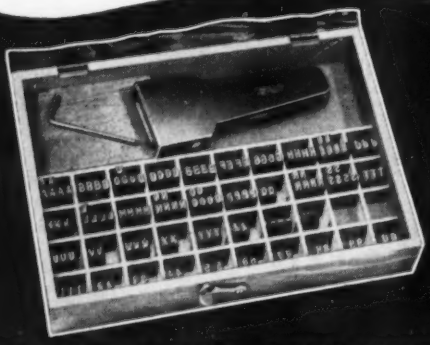


INTERCHANGEABLE TYPE and TYPE HOLDER SETS

The faces of CADILLAC Steel Letters and Figures combine a high degree of hardness with toughness, insuring especially long life. All CADILLAC Marking Type and the recess in Type Holders are made in standardized dimensions. This means that type will fit interchangeably in hand holders, marking machine holders or punch press holders designed for the size type specified. Due to the precision adhered to in manufacturing, they will when assembled in any holder make impressions in perfect alignment.

HEAVY BEVEL HAND STAMPS
CADILLAC Heavy Bevel Letters and Figures combine a high degree of hardness with toughness, insuring exceptionally long life.

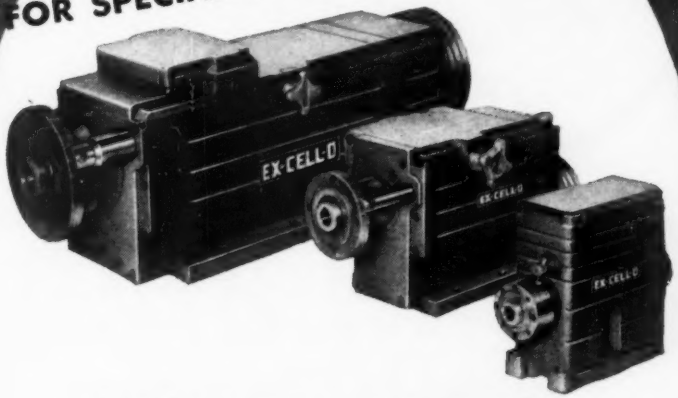
HAND STAMP SYMBOLS
A system of distinctive symbols for inspection and confidential markings. Write for Symbol Chart.

For full information write for Bulletin SE-130

CADILLAC STAMP CO.
FACTORY and OFFICES
17321 RYAN ROAD • DETROIT 12, MICH.

EX-CELL-O Hydraulic Power Units

FOR SPECIAL PURPOSE MACHINES



Ex-Cell-O Quill Type Hydraulic Power Units provide a compact, flexible source of power for feeding, rotating and retracting cutting tools. They are especially suitable for automatic drilling, reaming and counterboring, using a single tool held directly in the spindle, or using two or more tools in a multiple head. Three standard units are available—styles 28-A, 21 and 20, shown above. For full information send for Bulletin 45828.

XLO

EX-CELL-O CORPORATION

DETROIT 32, MICHIGAN

you can't buy a **better** "soft" hammer -anywhere!

C/R JAW-HEAD

NEW FACES IN SECONDS!

Just loosen a nut and old faces are easily replaced. Tighten nut, and faces are in vise-like grip.

There's plenty of power cushioned in the tough, resilient water buffalo faces that give delicate parts and fine finishes full protection. And faces are easily, quickly replaced. You have a comfortable, non-slip grip with the Safety-Flare handle. Work with the best "soft" hammer — make sure it's a C/R RAWHIDE Jaw-Head.

For further information write Dept. 22

Available from leading industrial suppliers. Also C/R Rawhide mallets and Rawhide mauls.

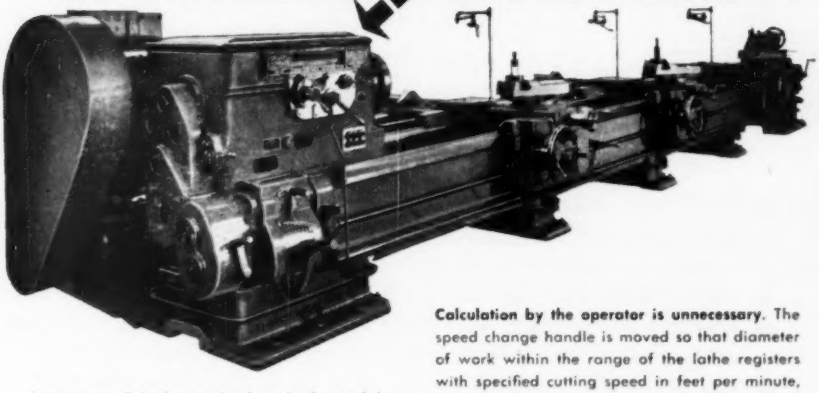
CHICAGO Rawhide MFG. CO.

1301 Elston Ave., Chicago 22, Ill.

In Canada: Super Oil Seal Mfg. Co., Ltd., Hamilton, Ontario

THE BIG HYDRATROL STORY:

16 Spindle Speeds *with only a* Twist of the Wrist... *with This Automatic Slide Rule Selection!*



Just a turn of the hand wheel on the front of the headstock of the LEHMANN Hydratrol Lathe gives you a speed change! An automatic slide rule, co-ordinated with the movement of the handle, shows spindle revolutions per minute and indicates a slide rule calculation of the cutting speeds in feet per minute.

Calculation by the operator is unnecessary. The speed change handle is moved so that diameter of work within the range of the lathe registers with specified cutting speed in feet per minute, and the lathe automatically makes the necessary change.

The rotary selector gives 16 forward and 8 reverse speeds. No need for intermediate stop; unnecessary to disengage the friction driving clutch to change speed.

Check These Other Important Advantages:

- **Safe in operation.**
- **Simplicity in construction and operation.**
- **Hydraulic friction clutches and hydraulic brakes, self-compensating.**
- **Automatic safety relay, for harmless and easy engagement of positive clutches when speeds are changed.**
- **Spindle release for chucking.**
- **Perfect, safety-control lubrication with filtered oil.**
- **Gears constantly in mesh.**

Write today for additional information or catalog — or — send prints for time- and-money-saving recommendation!

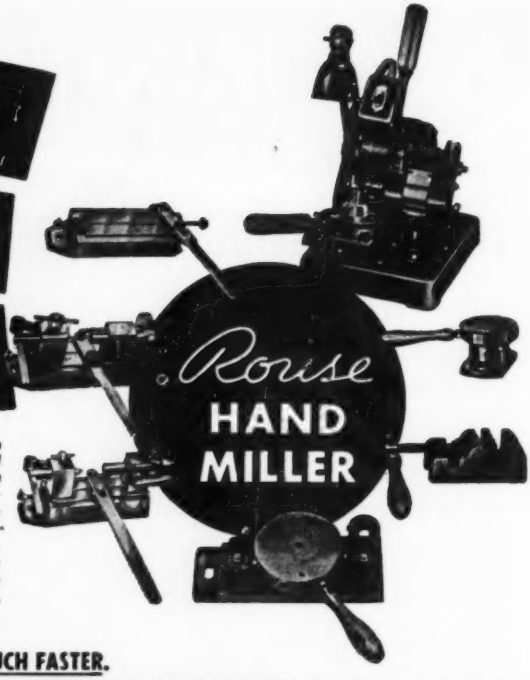
LEHMANN
MACHINE COMPANY
GRAND at CHOUTEAU • ST. LOUIS 3, MO.

DIVISION OF NOVO ENGINE CO.

INCREASES PRODUCTION...

LOWERS COSTS...

PAYS FOR ITSELF QUICKLY...



The ROUSE HAND MILLER is a widely used, inexpensive, high speed, ball bearing, motor driven machine for handling light cuts in brass, aluminum, steel, plastics, and other materials—fast, accurately, and at very low cost. Only $106.00. Fixtures (illustrated) extra.*

Motor equipment:—¼H.P. 110 Volt AC 60 cycle, single phase, swivel motor mount and light — $33.00.*

**All prices FOB Chicago.*

- ★ **MILLS SMALL PARTS MUCH FASTER.**
- ★ **DRASTICALLY CUTS YOUR INVESTMENT IN EQUIPMENT.** Replaces expensive production machinery—or releases it for other jobs.
- ★ **INEXPERIENCED HELP CAN OPERATE IT.** Safe, simple, fool-proof operation.
- ★ **NO MORE COSTLY SET-UP TIME.** $106.00* price so low that it pays to keep one or more Hand Millers always set-up for special operations.
- ★ **YOU GET A BETTER PRODUCT**—the result of ABSOLUTE ACCURACY.
- ★ **A LOSS BECOMES A PROFIT** when marginal pieces are finished on the Hand Miller instead of on high cost equipment.
- ★ **VERY LOW MAINTENANCE.**
- ★ **USED REGULARLY IN 1163 MANUFACTURING PLANTS** (some of which use as many as 30 machines)—yet on the market a scant few years.
- ★ **UNIQUE—VERSATILE.** Nothing else like it. One or several machines can be the answer to some of *your* production problems.

Write today for further information.

H. B. ROUSE & COMPANY

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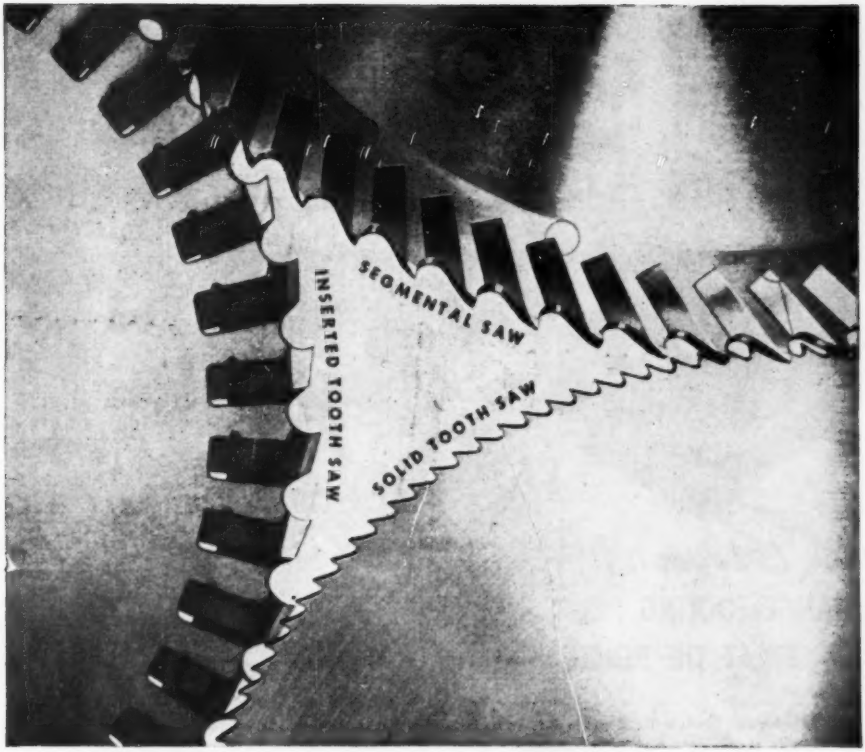
50 YEARS OF SERVICE TO INDUSTRY



"Pick your Teeth!"

For the best saw-performance on your job... SIMONDS gives you a choice of *All 3 Types!*

INSERTED TOOTH: For heavy production cutting of all steel, brass, copper, and aluminum. Alternating square and beveled teeth "tri-vide" chips for easy cutting and clearance. Teeth can be easily replaced, singly or in complete sets, in your own plant by any average mechanic.

SOLID TOOTH: For general shop cut-off jobs . . . for use on smaller automatic cut-off machines and for cutting jobs where narrow kerf is important.

SEGMENTAL: For especially smooth cuts on production work. High Speed steel toothed segments are securely held in a tough alloy plate by a special tongue and groove design, have quick clearance for faster, freer cutting.

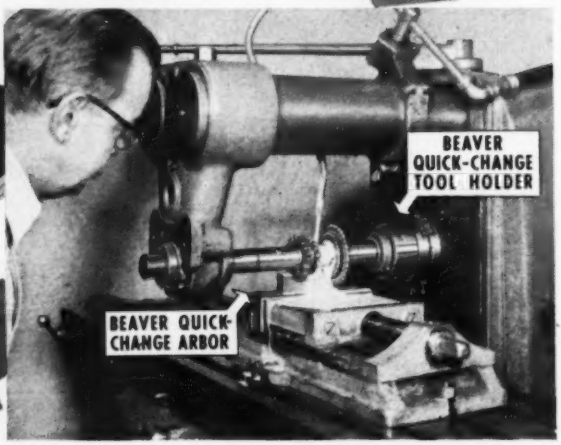
SIMONDS MAKES ALL THREE TYPES OF CIRCULAR METAL-CUTTING SAWS. So you can be sure that SIMONDS will give you *the right saw for your job* . . . for any type of machine. See your Simonds Distributor today, or write the nearest Simonds Office.

SIMONDS
SAW AND STEEL CO.
FITCHBURG, MASS.

Factory Branches in Boston, Chicago, San Francisco and Portland, Oregon. Canadian Factory in Montreal, Que. Simonds Divisions: Simonds Steel Mill, Lockport, N. Y., Simonds Abrasive Co., Phila., Pa. and Arvida, Que., Canada

Save MACHINE DOWN-TIME

WITH *Beaver* QUICK-CHANGE TOOLING PRE-SET AT THE BENCH



Beaver Quick-Change Arbors for all slotting, face, straddle, and gang milling save machine time, improve quality, and hold accuracy on single, multiple, and transfer machine operations.

By using Beaver Quick-Change Arbors in Beaver Quick-Change Holders on your machines, down-time can be confined to the bench. This allows uninterrupted machine operation without costly reset-ups with each change of tools.

Beaver Quick-Change Arbors reduce trial and error rejects by holding a constant relationship between the flange and the collar of the arbor. Spacing of cutters can be accurately predetermined at the bench with simple "Jo" blocks or height gage and indicator.

With Beaver Quick-Change Arbors your machines are free of costly down-time and cutter change from one set-up to another is a simple, quick operation. Prove Beaver Quick-Change Toolings superiority on your own operations.

STANDARD MACHINE TOOL ACCESSORIES CARRIED IN STOCK

Beaver TOOL AND ENGINEERING CORPORATION

BOX 429, ROYAL OAK, MICH., Teletype—Big Beaver 648

Lighter . . . faster Rotor grinders

"PAID OFF" in 48 days

JOB: Grinding welds on truck cabs. Using slow, 20-pound electric grinders. Only 2800 r.p.m. under load.

SOLUTION: Rotor Application Engineer suggested changing to Rotor 6" Air Grinders that weigh only 9¾ pounds. Speed 5300 r.p.m. under load.

RESULTS: Stepped up metal removal, increased wheel life. Lower maintenance. Cut man-hours per cab. Savings "paid off" cost of Rotor Grinders in 48 days—on basis of 50% use factor.

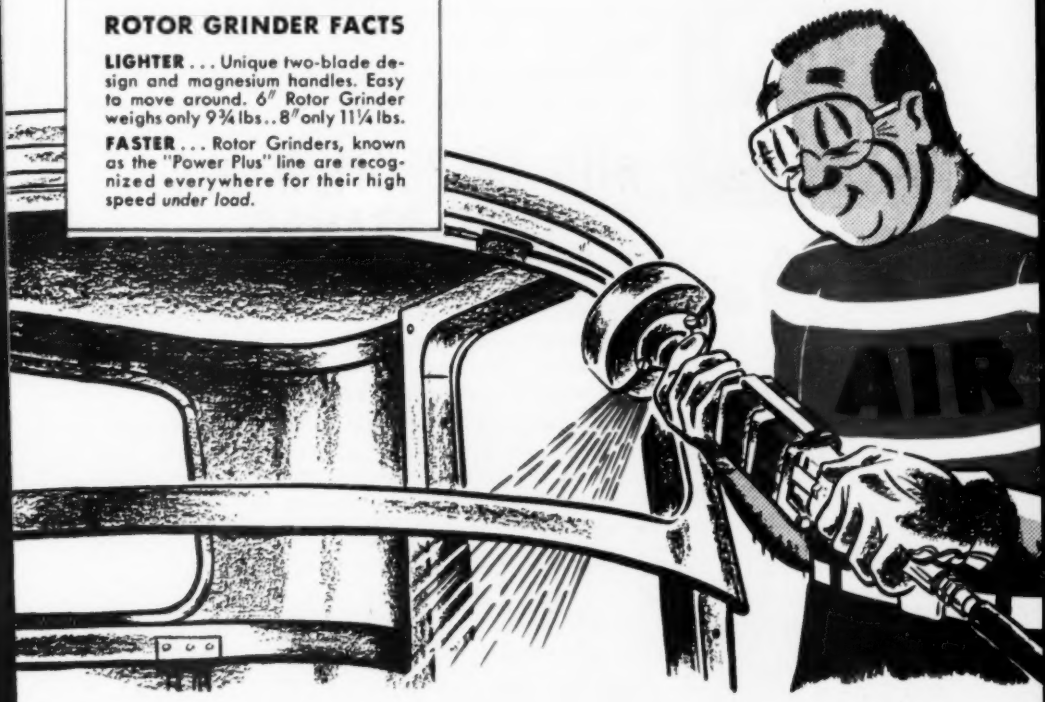
Call in your Rotor Application Engineer for a study of your portable tool operations to suggest improvements. Write for Catalog No. 38.

AIR O'TOOL

ROTOR GRINDER FACTS

LIGHTER . . . Unique two-blade design and magnesium handles. Easy to move around. 6" Rotor Grinder weighs only 9¾ lbs.. 8" only 11¼ lbs.

FASTER . . . Rotor Grinders, known as the "Power Plus" line are recognized everywhere for their high speed *under load.*



THE ROTOR TOOL CO.

CLEVELAND, OHIO

RETAIN CONTROL

with INSPECTION and CODE STAMPS

These inspection and code stamps enable a manufacturer to retain control of his product wherever it goes. A single glance can provide such information as the identity of a welder, inspector, operator, or assembler—heat number, lot number, material or date of manufacture.

Choose your own code from any of 300 stock designs, available in any desired size, in either the economical HI-DUTY Brand or even longer-lasting HI-LOY Brand. You'll get permanent identification through use of code designs, with key letters or figures if desired.

"IF IT'S WORTH MAKING, IT'S WORTH MARKING"

Geo. T. Schmidt marking engineerings will help you develop a code control plan without obligation. Write for particulars.

GEO. T. SCHMIDT, INC.

1802 Belle Plaine Ave. Chicago 13, Ill.

Faster ANGULAR SET-UPS WITH GAUGE BLOCK ACCURACY

MAGNA-SINE

ON angular set-ups the Magna-Sine saves hours of set-up time, provides positive accuracy, holds work securely without distortion.

The Magna-Sine is a quality permanent-magnet chuck mounted on precision hardened and lapped hinged plates. A Table of Constants provided, quickly shows the standard gauge blocks to insert between the plates for any angle—single or compound. Set-ups to gauge block accuracy take minutes, not hours! When closed, the Magna-Sine is used as a conventional magnetic chuck. Thousands are in daily use.

Write for your free copy of the Magna-Sine Catalog which shows all styles and sizes . . . price list is included.

OMER E. *Robbins* COMPANY

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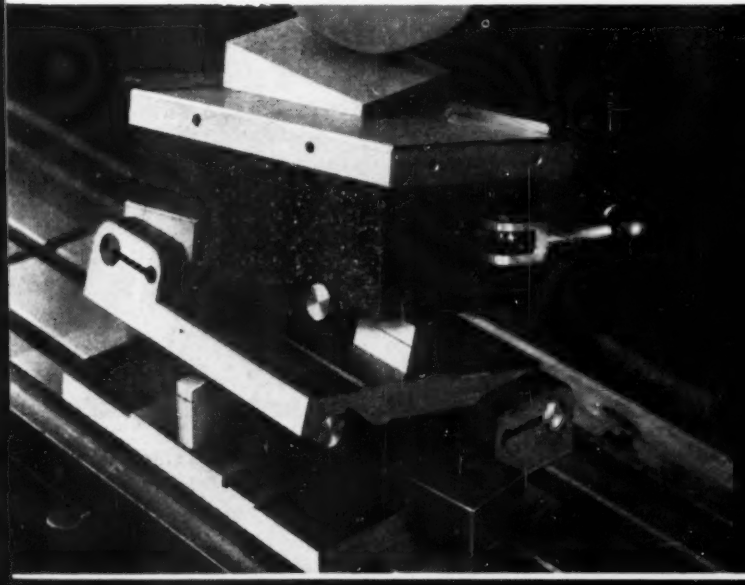
Also producers of special gauges and fixtures



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GRINDING
INSPECTION
DRILLING
BORING

AT ANY ANGLE

Specialists in Tungsten Carbide Tools

They're Precision Machine Ground-From-The-Solid

Quality Engineered } BURS, REAMERS, END MILLS
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Representatives and Distributors in principal cities in the United States and Canada. Write us for the name and address of our Representative in your area.

Send for complete catalog NOW!

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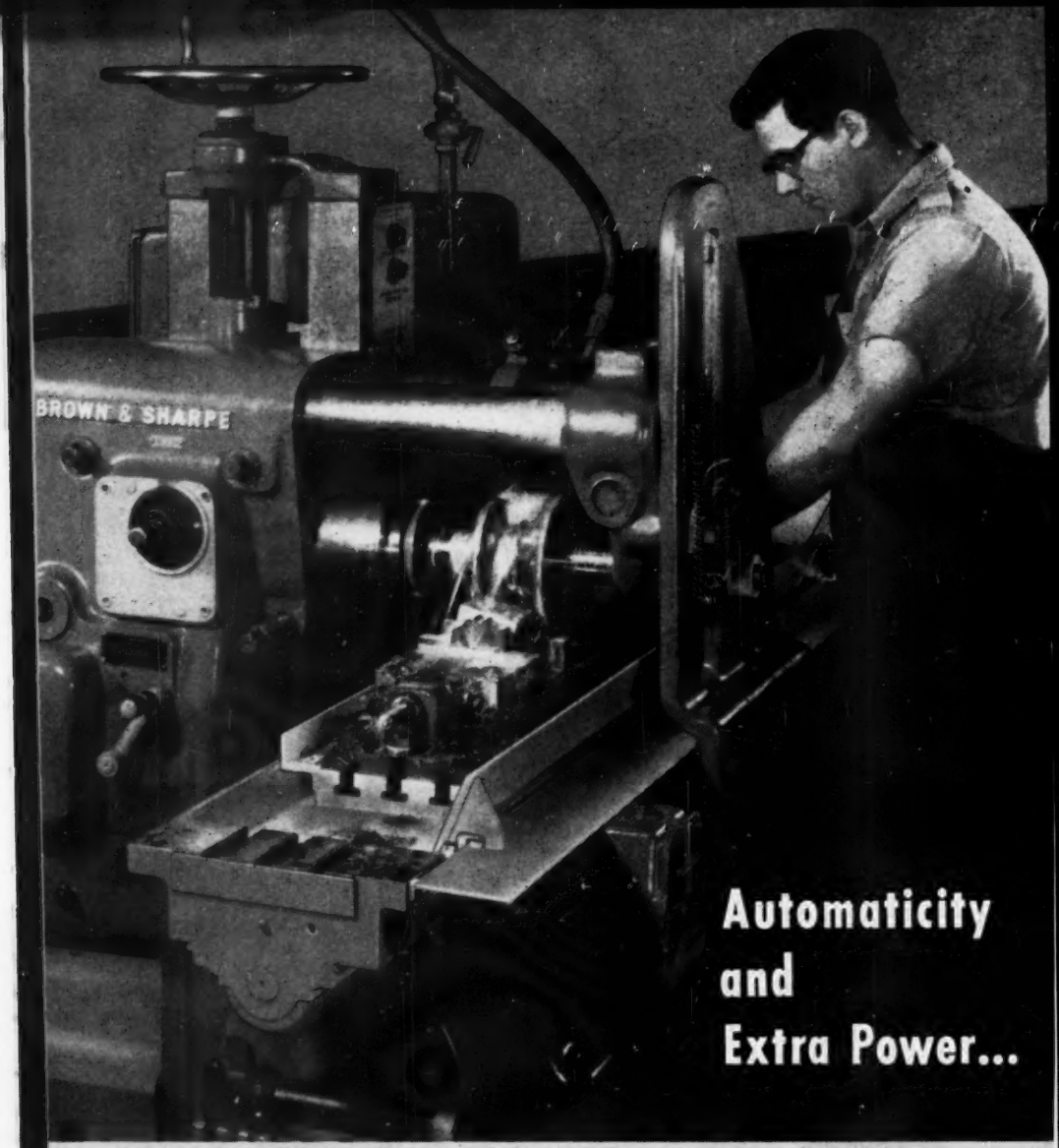

. . . the 7½ H.P., electrically-controlled No. 12 Plain Milling Machine. You get full 7½ H.P. right at the spindle plus "push button" or automatic control of all power movements for rapid production on both long and short run jobs. Dual feed rates, a variety of automatic cycles, and the ability to climb mill in either direction are just a few other time-saving advantages. Write for complete details.

Brown & Sharpe Mfg. Co.,
Providence 1, R. I., U.S.A.

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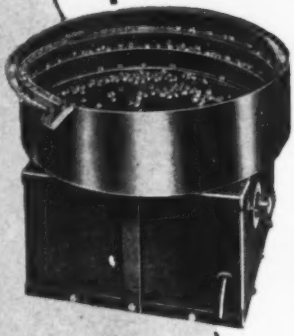
Announcing . . .

a New addition to our popular line of SELECTIVE FEEDING DEVICES

NOW! A FEEDING UNIT FOR ALMOST ANY SPECIFIC APPLICATION!

Also EXTENDED ENGINEERING SERVICE—
ENABLING US TO DO THE COMPLETE TOOLING FOR YOUR INDIVIDUAL FEEDING OPERATIONS

New!



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A proved method based on the VIBRATORY PRINCIPLE. Provides fully automatic, oriented, single line feeding to Grinding, Packaging, Inspecting and many other automatic machines and operations. Will scientifically feed light, fragile parts that normally could not withstand tumbling.

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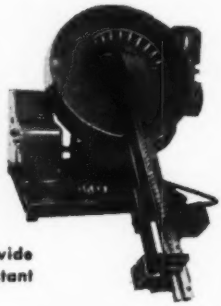

For years our popular unit, successfully used in thousands of plants to help speed production and reduce costs. They were designed with the idea of simplicity in operation and maximum feeding, handling a wide variety of parts. Designed for constant operation.

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Give Details and learn how our trained engineers can supply the answer to your feeding requirements

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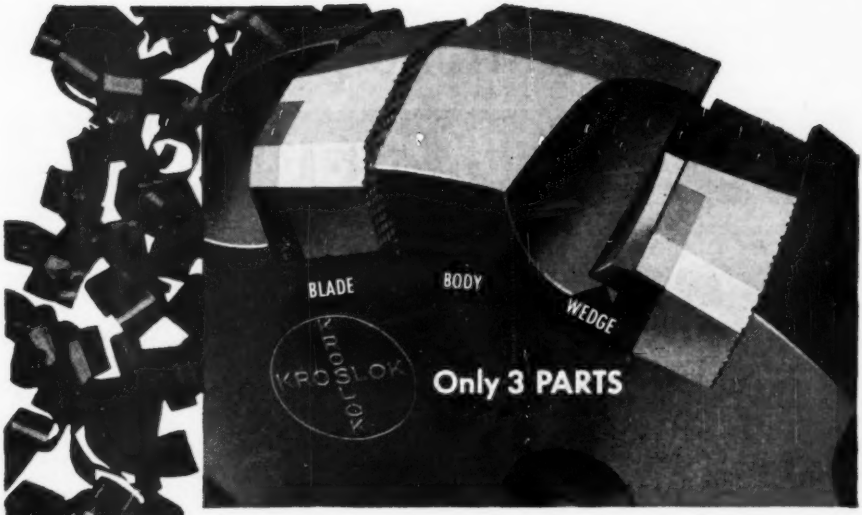
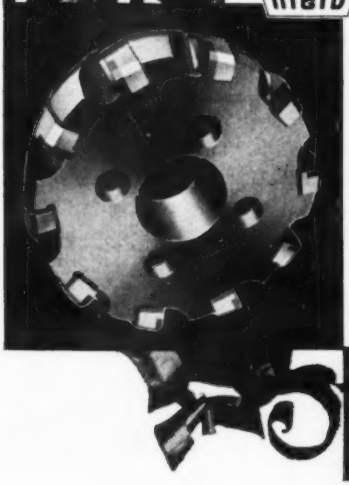
2809 W. FORT ST. DETROIT 16, MICH.



You're "in the Chips"

WITH THE MOTCH & MERRYWEATHER KROSLOK FACE MILLING CUTTER AND SHELL END MILL



A real *blue chip* investment — KROSLOK. Be sure of positive blade holding which is obtained by immovable wedges and cross serrations mating between body and blade. Extra rugged construction! Reach new production highs by long, uninterrupted service. Make milling more profitable through higher speeds and heavier feeds. *Only three members!* General purpose and heavy duty bodies, each for ferrous and non-ferrous applications; special KROSLOKS to order.

THE MOTCH & MERRYWEATHER MACHINERY CO.

Cutting Tool Manufacturing Division
Cleveland 13, Ohio

in air turbine grinders

YOUR BEST BUY IS BUCKEYE

here's a brand new air turbine grinder especially for carbide cutting!

FAST—
55,000 RPM

POWERFUL—
Full ¼ HP

LIGHTWEIGHT—
Just 1¾ Lbs.

More power per pound! That's the reason the NEW Buckeye Air Turbine Grinder will cut through grinding jobs faster, with less effort for the tool operator. Versatile—designed for use with tungsten carbide burrs, adaptable to use with rotary files and midget mills, may be mounted on tool post, takes mounted points up to ¼" shank.

Write NOW for complete information on this NEW addition to the Buckeye Tools line of 56 portable air-powered grinders.

Buckeye Tools
CORPORATION
DIVISION 14 • DAYTON 1, OHIO

producers of the world's first successful rotary air tools

Give Your Ejection Problems the Air

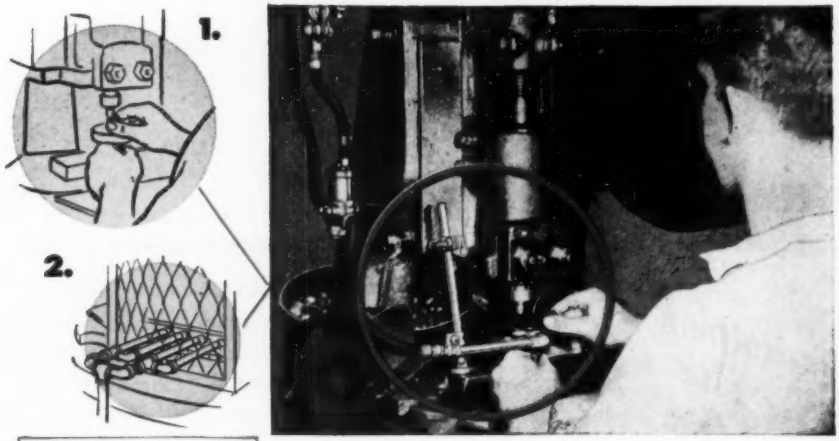
...and boost production and safety

❶ End dangerous hand removal of work with Schrader Air Ejection. Install Schrader Air Ejection Sets on your power presses. Production soars—up to 100% . . . operator safety is boosted 50%. Replace hand removal with Schrader Air Ejection and watch your presses take a new lease on life.

❷ Replace homemade steady air blasts with Schrader Air Ejection. Air costs drop up to 90% because Schrader Air Ejection Sets ration out *just enough* air to do the job . . . synchronize air blasts with demand. Before you decide your compressors have reached capacity, check with Schrader.

Schrader Air Ejection Sets are delivered fully assembled, ready to go to work. Their cost is more than repaid in a few weeks.

See how Schrader Air Ejection will help you plan more effective machine use. Write, describing the machines on which their use is contemplated—or fill out the coupon below.



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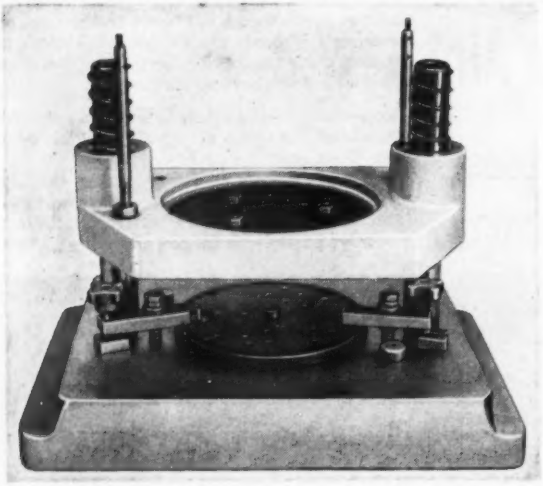
HERE'S THE NEW Zagar Standardized Self-Clamping DRILL JIG



Zagar Drill Jigs are used in conjunction with Zagar gearless multiple-spindle drill heads to ream, drill, tap on standard drill presses and tapping machines.

4 types—9 sizes, 5 combinations per size—hole patterns 3" through 15" dia.

Nothing Else Like It!

SPEEDY — ACCURATE — RUGGED . . . A new concept to reach new production highs! Standardization means quick delivery and attractive price, since only a very few minor parts have to be made. Extremely fast; the operator merely feeds the parts — the Zagar Self-clamping Drill Jig does the rest. Proven design insures maximum accuracy.

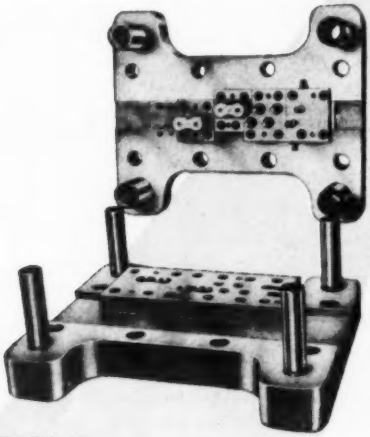
Ask for Our New Data Sheet "B-1".

ZAGAR TOOL, INC., 24000 LAKELAND BLVD., CLEVELAND 23, O.

Zagar TOOLS FOR INDUSTRY and SPECIAL MACHINERY

WHITNEY CHAIN

links up with... PRODUCTO DIE SETS



MATERIAL

¼" SAE 3140 hot rolled steel in coiled stock.

OPERATIONS

Station No. 1 — Whitney Chain markings clearly embossed on each link.

Station No. 2 — Four holes, two to a link, rough pierced.

Station No. 3 — Two chain links blanked out on each press stroke.

TOLERANCES

Hole diameter + .0005" — .0005"
Hole centers + .001" — .001"
Link Contour + .005" — .010"
Die Set face parallel to feed slot + .002" — .002"

PRODUCTION RATE

153,000 links blanked per 40 hour week.
Between grinds, 75,000 pieces.

NEED PROMPT SERVICE? CALL YOUR NEAREST PRODUCTO ASSEMBLY BRANCH

Tough, ¼ inch-thick hot rolled steel chain links are not an easy stamping job . . . especially when heavy production must be matched with close tolerances and excellent finish.

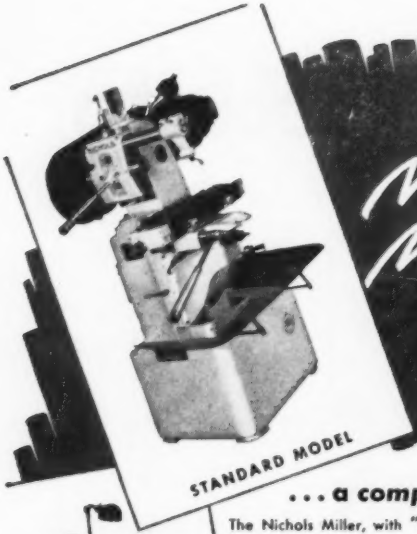
Here are the figures as this job rolls along at Whitney Chain on Niagara presses equipped with PRODUCTO 4-pin progressive die sets. It's typical of the way Producto Service teams up to set production records.

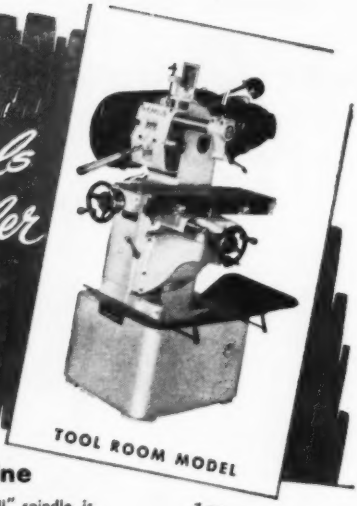
THE PRODUCTO MACHINE COMPANY
960 Housatonic Ave., Bridgeport 1, Connecticut

For Precision Die Sets *Fast* Call . . . PRODUCTO

ALSO MAKERS OF TOOL AND DIEMAKERS ACCESSORIES, VISES, MACHINERY

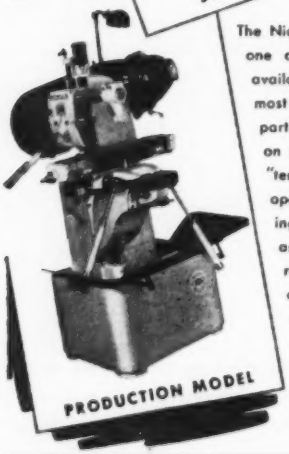
Nichols Miller





. . . a *complete* line

The Nichols Miller, with "rise-and-fall" spindle, is one of the most precise, universal machines available today. The four models shown, fill most basic requirements—whether for single parts with simple set-up, or multiple operations on mass production jobs with tolerances to "tenths". Their versatility makes possible such operations as facing, boring, recessing, turning, slotting, key seating and contour milling, as well as regular milling. According to requirements, screw or lever longitudinal and transverse table feeds are available optionally. "The miller that uses its head" is your best choice—and one of industry's greatest values. If you want production to "tenths", investigate the Nichols Miller.



"the miller that uses its head!"

Write today for the Nichols general catalog, which describes the six models of Nichols Millers. A sound, color movie "The Miller that Uses its Head" is available for free showing. May we reserve it for you?

CONDENSED SPECIFICATIONS

Table Working Surface	6¾" x 21" or 30"
Longitudinal Travel (screw or lever)	10" or 19"
Transverse Travel (screw or lever)	7"
Vertical Travel — Knee	13½"
Rise and Fall of Spindle	4½"
Selective Speed Ranges up to 5000 R.P.M.	
Weight	1250 lbs.

MANUFACTURED BY W. H. NICHOLS COMPANY WALTHAM, MASSACHUSETTS

NATIONAL DISTRIBUTORS **NICHOLS-MORRIS CORPORATION**

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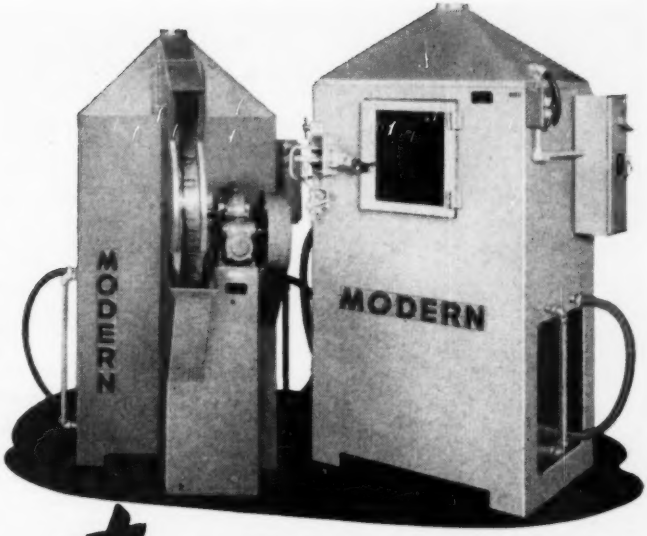


Larger parts are deburred in Maizo Blast machine (right) with stationary fixture. Operation is automatic when door is closed. Small parts are deburred in model with continuously rotating ferris-wheel type fixture (left).

Blast THOSE BURRS!
with Modern Maizo Blast

If you're being plagued with light burrs on high-production metal parts, get Modern Maizo Blast equipment and forget them.

Simply load the parts into a continuously rotating fixture if they're small—larger parts are placed on a stationary fixture in a door-operated model. The rest is automatic. A blast of high-pressure air containing ground maize or walnut shells quickly whisks off burrs. Proper blasting material enables you to deburr without pitting finished surfaces.

Outstanding performance and quality are notable features of Maizo Blast equipment. That's because it's made by the maker of the famous Burr-Masters, the fastest production gear burring and chamfering machines available. Modern has put the same "know-how" into the Maizo Blast design to give the utmost in operating efficiency.

Write today for Bulletin 103-57 covering Maizo Blast equipment for both small and larger parts.

MODERN
Industrial Engineering Co.
14230 BIRWOOD AVE
DETROIT 4, MICH.

ELGIN
MILLING MACHINES

TOOL ROOM PRECISION WITH PRODUCTION SPEED

. . . that's what you expect and get from Elgin Machine Tools. They are designed and built to tool room standards, to perform to close tool room tolerances . . . and with sturdiness permitting speed that fits right into production lines.

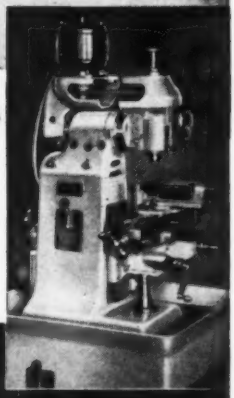
Elgin Lathes and Milling Machines are standard equipment in many tool rooms and shops where extreme accuracy is necessary.

HORIZONTAL MILLING MACHINE

Spindle of nickel steel, hardened and ground externally and internally, and fitted with pre-loaded ball bearings. Speeds, 85 to 2750 R. P. M. with Variable Speed Drive, directly reversible. Table, 4⅛" x 18" with longitudinal travel 12"; transverse, 6", vertical, 6". Two-speed motor, ¾-⅜ H. P.

VERTICAL MILLING MACHINE

Spindle is nickel steel, hardened and ground both externally and internally, and fitted with pre-loaded ball bearings. Five speeds, 200, 700, 1250, 2250 and 4000 R. P. M. Vertical travel of spindle, 1¾". Table is 4⅛" x 18" with 12" longitudinal travel; transverse travel 6". Vertical table travel 7". Head swivels 90° each side of center.



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1772 BERTEAU AVENUE — CHICAGO 13, ILLINOIS

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HYDRAULIC CYLINDERS

HARD CHROME PLATED PISTON RODS
Prevent Scratch-Damage, Nicks and Rust

SOLID STEEL HEADS, CAPS and MOUNTINGS
Eliminate Breakage

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Protect Rods, Seals, Bushings

Standard Leather Cup Seal Assembly Shown Is Interchangeable With Miller Standard Piston Ring Piston Assembly

WRITE FOR CYLINDER BULLETINS H-104 and A-105

Complete Miller cylinder line includes: air cylinders, 1½" to 20" bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

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MILLER MOTOR COMPANY

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AND

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All parts hardened and ground. Simplicity of construction insures trouble-free operation. Gripping power of non-slipping "Wille-Grip" chuck automatically adjusts to load requirements.

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QUICK CHANGE COLLET

"WILLE-GRIP" KEYLESS DRILL CHUCK

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- Tapping Attachments
- Milling Machine Arbors, Adapters, Arbor Spacers & Bearings
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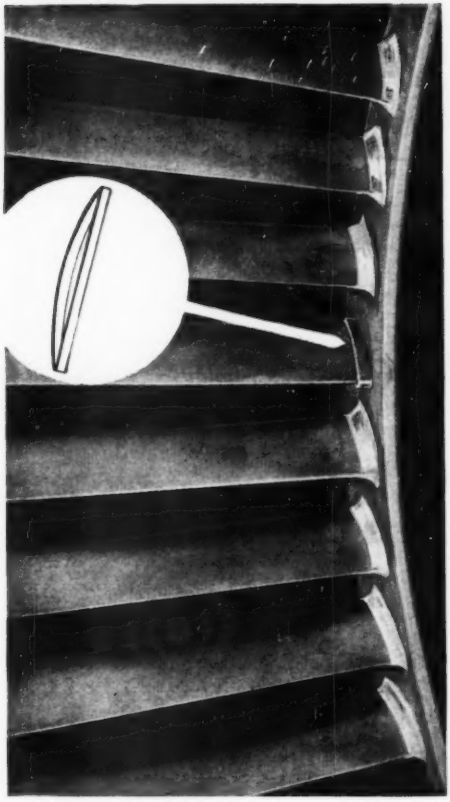

Jet Turbine Blade Assemblies

SILVER BRAZED

WITH LM STRESS RELIEVED

FLAT WIRE PREFORMS

L. M. Preforms Solve Complicated Series Brazing Problem for Large Aircraft Manufacturer

Regardless of what your joining and silver brazing operations are it will pay you to consider L.M. Preforms.

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Replaceable Die Shank Bushing	✓	
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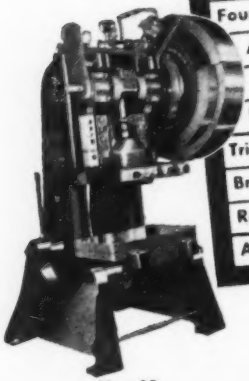
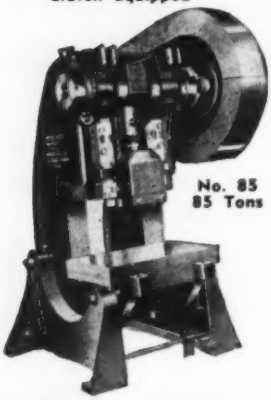


No. 60
60 Tons—Air Clutch Equipped



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85 Tons

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Now You Get All These Features in **One** Press . . . the Press-Rite Press. Buy Press-Rite Presses today and get increased production . . . longer die life . . . greater operator confidence . . . longer press life . . . and scores of other benefits. Press-Rite Presses help to cut your operating expenses and eliminate costly down time. Get all the facts find out about our Press-Rite Presses Today. Send for Bulletin P552.

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SSMT

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OSBORN

This wheel of fortune pays 20 to 1 on every turn

In one minute this machine does a job that formerly required 30 minutes! It shows what *you* can do with new OSBORN Power Brushing techniques to speed *your* production and cut costs.

The job consists of deburring ends of stainless steel blades of a jet engine stator assembly. Chucked up in a grinder, as shown, the assembly rotates counter-clockwise at 20 rpm. An 8-inch grinding wheel grinds the ends of the vanes. Burrs and feather edges are then removed by two OSBORN 10-inch Monitor® Brushes rotating at 2800 rpm—45 seconds in each direction. The complete cycle takes 1½ minutes. Vane ends are made uniformly smooth, 20 times as fast as former hand method.

The answer to *your* production problems may be found with special Osborn-equipped machines such as this . . . or with one of the Osborn Brushing Machines which are being used in scores of plants for high-speed deburring. For *any* problem in deburring, cleaning and finishing, start tackling it with the powerful experience of your Osborn Brushing Analyst. Call him or write *The Osborn Manufacturing Company, Dept.* **L-5** *5401 Hamilton Avenue, Cleveland 14, Ohio.*

FREE: New booklet on deburring with Osborn Power Brushing. Write for your copy.

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BURR • FINISH • CLEAN • POLISH

Both CONVEX and CONCAVE SURFACES

Like This Jet Rotor Blade ▶

IN ONE OPERATION

Have you contouring work comparable to the finishing of the jet engine rotor blade? Does it necessitate costly, step-by-step operations? Does it entail working in metal, plastics, wood or laminated materials? Are you looking for simplified procedure, fewer operations, in the finishing of products, parts or assemblies? Whatever your project, it will pay you to investigate abrasive-and-rubber Brightboy. The simultaneous action of Brightboy's abrasive and rubber will surprise you!

The soft rubber binder "cushions" the uniformly dispersed abrasive. Rubber and abrasive together create a unique action, a light finish, which bridges the gap between the rough grind and buff in one operation! Time savings can amount to fifty per cent!

Brightboy will achieve a wide variety of finishing effects, the desired finish being obtained by speed and/or pressure of the Brightboy wheels, sticks, rods or blocks used in the machine or manual operation.

TRY A TEST! Ask your dealer for the Brightboy Sample Card and the Brightboy Catalog-Manual. Write us on any problems where finishing is involved.

WHEELS, STICKS, RODS, BLOCKS for machine and manual operations

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RUBBER CUSHIONED ABRASIVES

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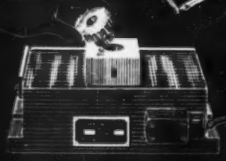
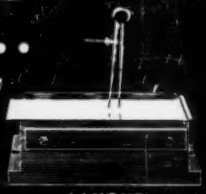
SMALL CHUCKS
FOR THOSE SMALL JOBS...

FIXTURES

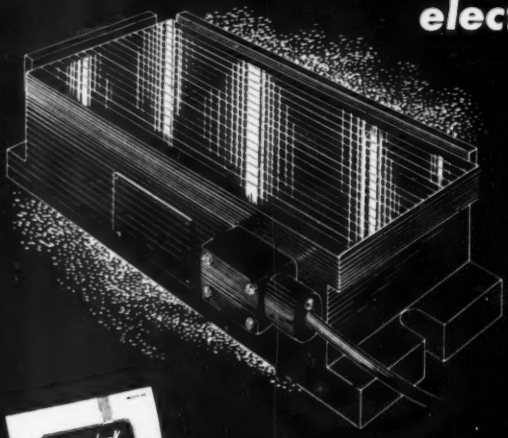


HAND SAWING



LAYOUT

it's
Magna-Lock
electro-magnetic CHUCKS



5" x 10"... 6" x 12"... 6" x 18" working surfaces. Ideal for bench work, small machine tools. 22% more holding power . . . moisture proof . . . other advantages of larger Magna-Lock Chucks. Complete with rectifier and switch for operation on A.C. voltage.

Price: 5 x 10 ..... $125.00
6 x 12 ..... 159.00
6 x 18 ..... 225.00

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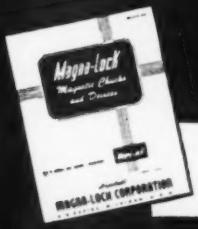

Get details...
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Magna-Lock

Hanchett MAGNA-LOCK CORPORATION
Magnetic Chucks and Devices
BIG RAPIDS . . . MICHIGAN, U. S. A.

Introducing...

FIRST HIGH-SPEED, LOW-COST PROCESS OF COLD FORMING AND WELDING

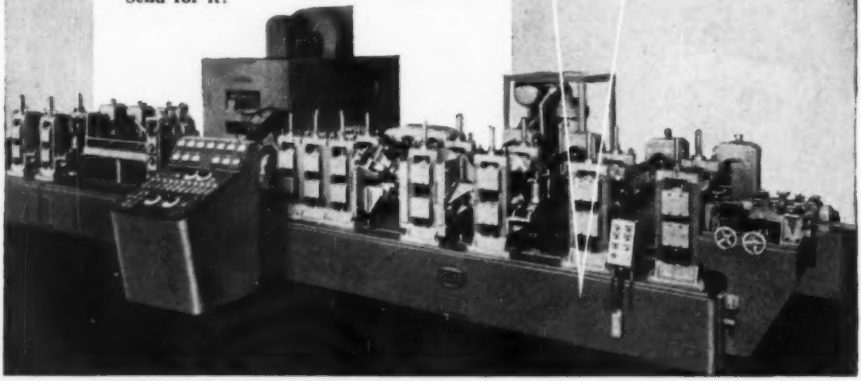
NON-FERROUS TUBING

ALUMINUM · MAGNESIUM · NICKEL · BRASS AND OTHER ALLOYS

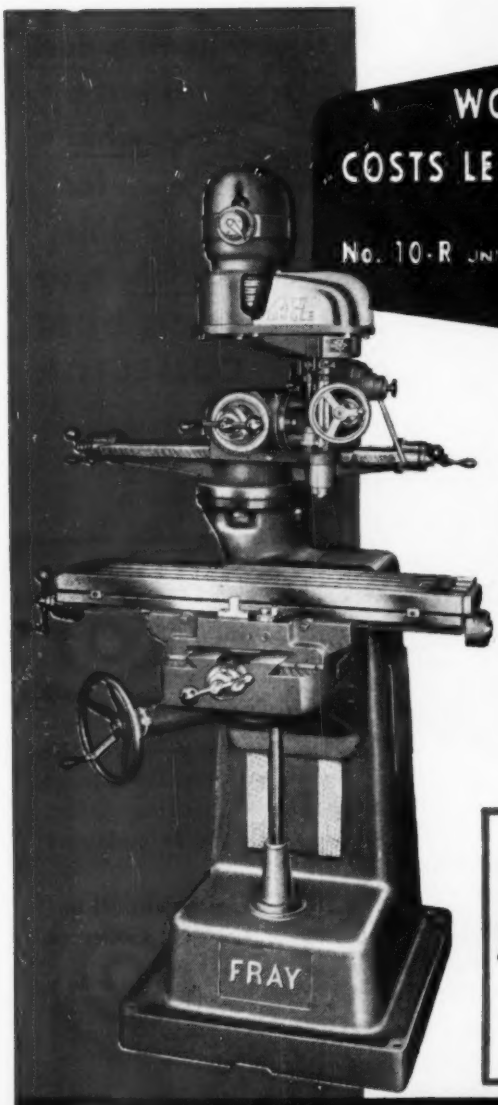
● Speeds range from 30 to 120 fpm, depending on gauge and kind of metal. The process makes possible the conversion into tubing of coiled strip in gauges from 0.156" all the way down to 0.025", *without drawing and annealing.* This means drastic reduction in the cost of making non-ferrous tubing. The lighter the gauge, the greater the saving.

Thus, for the first time in tube making history, through an exclusive Yoder development, coiled non-ferrous strip can be converted into high grade tubing entirely by cold process, at speeds approximating those employed in making steel tubing by resistance-welding. Non-ferrous producers as well as fabricators using tubular components will be interested in the story of this epoch-making development. Send for it!

ENGINEERING YODER MANUFACTURING



THE YODER COMPANY • 5509 Walworth Ave., Cleveland 2, Ohio



WORK MOVES FASTER
COSTS LESS with a Fray
No. 10-R UNIVERSAL RAM • TURRET TYPE • VERTICAL
MILLING MACHINE

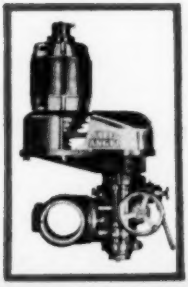
You get a wider work range than with any other machine this size. You can machine at *any* angle—vertical, horizontal or both. You can mill, drill or bore at any angle. Hence resetting isn't necessary. Just change the machine—changing is quick. (For vertical and regular horizontal milling, use the 10-RH.) Jobs are done faster and better ...at less cost. • It's Universal • Rugged • Easy to Operate.

A high precision tool.

Write for details and specifications.

Bulletin 10.

FRAY "ALL-ANGLE" HEAD TYPE 4



For deep, heavy cuts. Permits working to extra close limits. Any angle up to compound 2-way. Request Bulletin 4.

All-Angle

FRAY MACHINE TOOL CO.

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DUST COLLECTORS

collecting dust is just a whirl for this cyclone type **TORIT DUST COLLECTOR**

TORIT GIVES:

- Easy installation
- Efficiency
- Minimum piping
- Low operating cost
- Easy cleaning
- Long service life
- Small floor space
- Adaptability
- 10 basic models

Here a Torit 19-FB Dust Collector and Torit Wheel Hoods effectively solve the dust problem for a large double-end polishing lathe. No lint or polishing dusts escape to endanger working conditions.

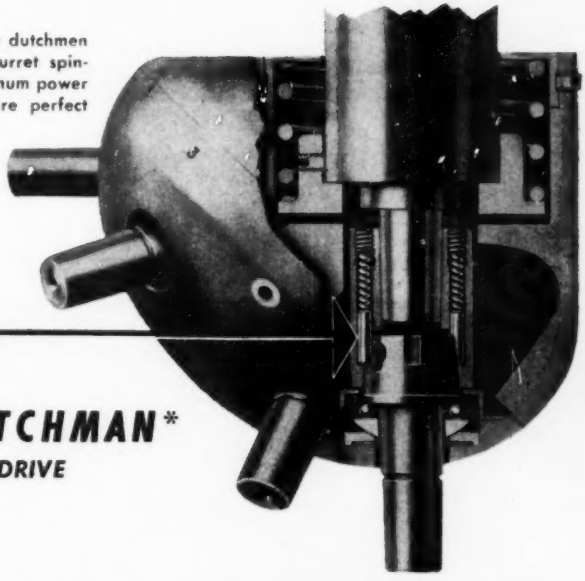
Up to 95% of the dusts spin into the pull-out drawer in the base of this Torit Dust Collector and the remainder is trapped in the after-filter bag.

Torit Dust Collectors are turning in top performances in every type of industry. They will star for you. Write for information.

see our catalog in MACHINE TOOL CATALOGS or write for copy

TORIT MANUFACTURING COMPANY
303 WALNUT STREET ST. PAUL 2, MINN.

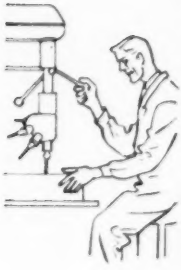
Two spring loaded pins or dutchmen automatically lock each turret spindle to the driver for maximum power while mating tapers assure perfect alignment



NEW

FLYING DUTCHMAN*

POSITIVE DRIVE



FOR MORE HOLES PER HOUR PER DOLLAR WITH LIGN-O-MATIC® SELF-CENTERING TURRET

SPEED — 6 consecutive operations on one standard drill press — no time lost changing tools or moving work.

POWER — Any tools your ½ in. chucks can hold and your drill press can drive in any material.

ACCURACY — Exclusive self-centering feature insures perfect alignment — CUTS tool and fixture wear.

PRICE — MODEL E — FOB So. Norwalk, Conn. $285.00

**Trade Mark*

Please send Bulletin 5312, containing complete specifications.

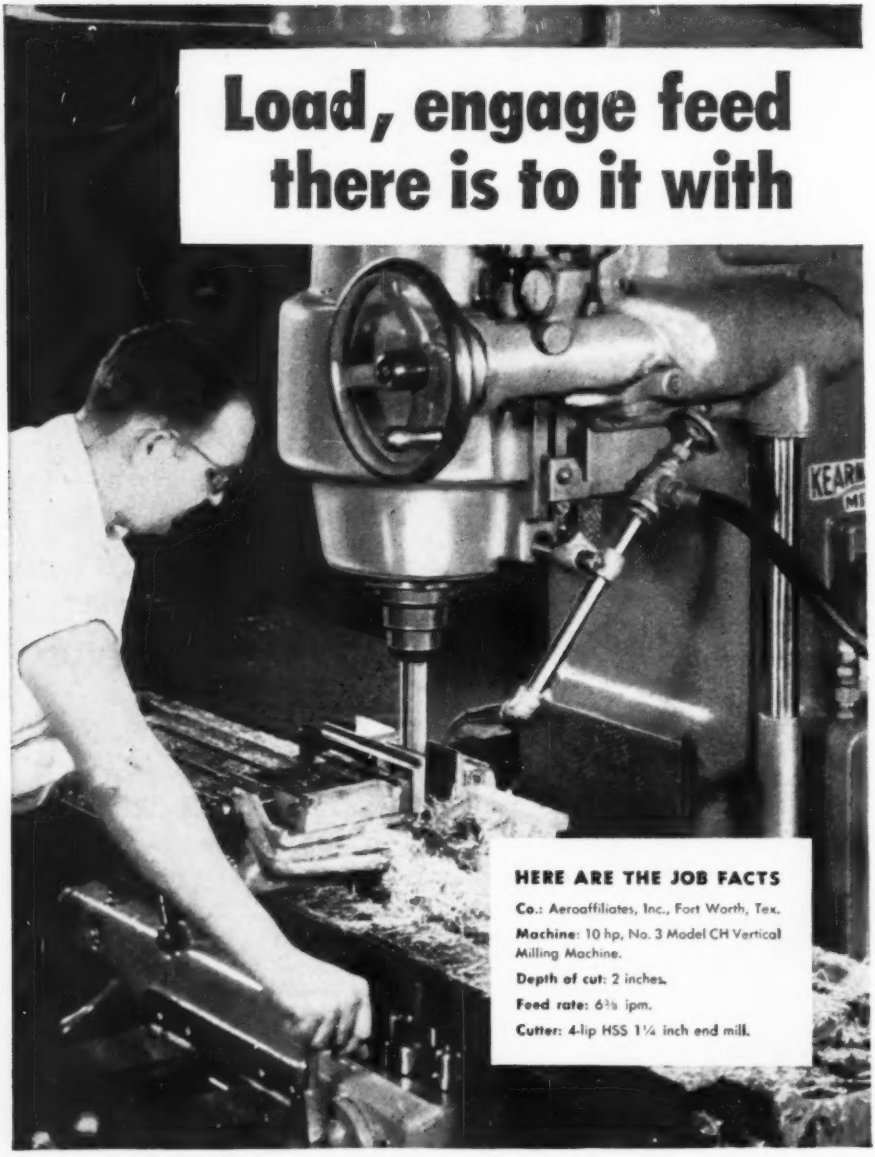
NAME _____

TITLE _____

(Attach to company letterhead)

HOWE & FANT, INC. 541 FLAXHILL ROAD SO. NORWALK, CONN.

Load, engage feed there is to it with



HERE ARE THE JOB FACTS

Co.: Aeroaffiliates, Inc., Fort Worth, Tex.

Machine: 10 hp, No. 3 Model CH Vertical Milling Machine.

Depth of cut: 2 inches.

Feed rate: 6⅜ ipm.

Cutter: 4-lip HSS 1¼ inch end mill.

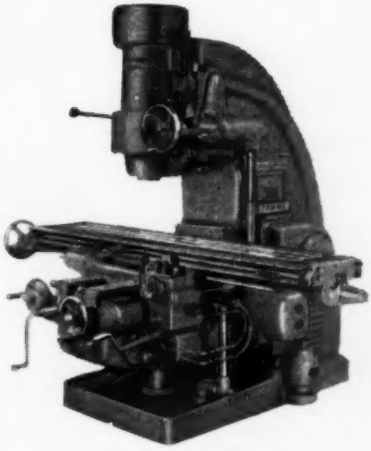
and unload—that's all this CH miller!

CH Vertical Milling Machine with *Mono-Lever and Automatic Cycle Table Control*, speeds milling of aircraft parts and reduces operator fatigue!

TO finish-mill aluminum vertical beam fittings, this manufacturer put production on an almost automatic basis without sacrificing accuracy. He's handling the job on a 10 hp, No. 3 CH Vertical Milling Machine equipped with Mono-Lever and Automatic Cycle Table Control.

Now, after the original setup, all the operator does is load the machine, engage the feed and unload. Production is up, accuracy is maintained and operating conditions have been greatly improved to the reduction in operator fatigue.

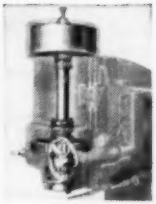
See how you, too, can cut costs, increase productivity, improve safety, get better finished products. Contact our representative or write Kearney & Trecker Corp., 6784 W. National Ave., Milwaukee 14, Wis.



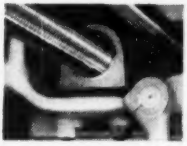
10 hp, No. 3 Model CH Vertical Milling Machine

CH Milling Machine features that helped increase output — cut cost per piece

Greater Operating Convenience through Mono-Lever control facility (optional at extra cost) for table feed and rapid traverse.



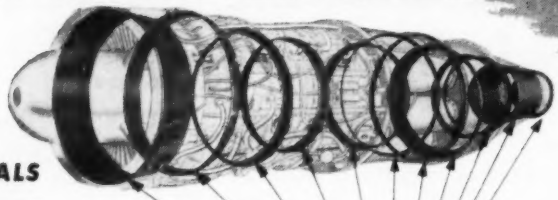
Greater Cutting Efficiency through spindle-mounted flywheel, (optional on CH Models) running with three bearing support.



Smoother Feed Performance through large dia. heavy-duty table feed screw that affords greater bearing contact, runs through extra-long table feed nut. All models are equipped with backlash eliminator.

KEARNEY & TRECKER MILWAUKEE MACHINE TOOLS

ADVANCED TECHNIQUE in Jet Ring Production



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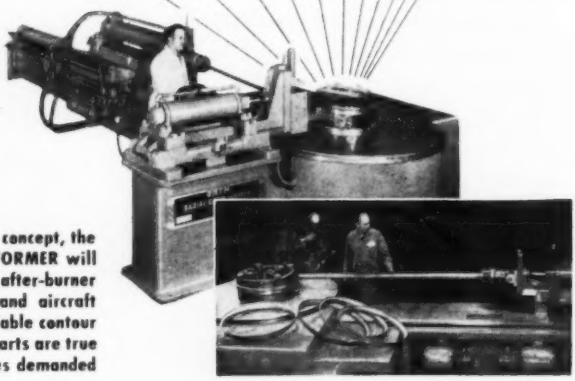

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Featured IN THIS ISSUE

1. History . . . Types . . . Operations . . . Parts of Jet Engines **147**

BY WILLIAM F. SCHLEICHER

The Italians and Germans had jets in the air during World War II. The English and Americans didn't begin serious work on jets until the outbreak of the war. Of the various types of jets the two most popular are the axial-flow and centrifugal-flow types. The various parts of the axial-flow turbine are discussed in some detail.

2. Aircraft Gas Turbines Produced in America and Europe **164**

BY PAUL H. WILKENSON

There are only a handful of jet engine manufacturers in the world, but there are thousands of manufacturers producing component parts. The author discusses the various types of jets produced here and abroad and the types made by each country. The majority of the larger manufacturers are producing axial type turbojets.

3. Latest Developments . . . Carbide Machining of Heat and Corrosion Resistant Metals **181**

BY FRED W. LUCHT

Among the metals used in jets are stainless steels, alloy cast irons and others. These materials are not difficult to machine, merely different. Several factors must be observed when machining these materials: the tool; machine tool; setup; operating conditions. The author analyzes each factor and gives specific instructions regarding cutting angles. This article reflects the latest findings and incorporates the latest carbide machining techniques on the new materials. Feature is the machinability chart on page 194.

4. Machining the Aviation Gas Turbine High Temperature Alloys **206**

BY D. C. Goldberg and H. O. J. HANZLICK

For easier analysis the authors have broken the jet engine down into four main sections and discuss the various materials in relation to them. The types of materials used in each section, as well as the machining of them, are discussed in practical terms. It must be remembered that the discussion centers around Westinghouse's J34; however, the materials and their machining problems are true regardless of the part and the use thereof. This article reflects the latest developments and is based on recent research.

5. Tooling and Welding Aft Frames at Ryan Aeronautical **227**

The aft frame is the structural member which holds the compressor, liners, turbine and compressor case together. Some of the welding applications are ingenious and require special machines.

6. Prime Contractors and Sub Contractors Produce Jets and Components **232**

These are shop shots gathered from various sources (as many as restrictions allowed).

7. Conserve Critical Materials by Ceramic Coating of Jet Engine Hot Parts **244**

BY J. V. LONG

It is hard for us to realize that we are a have-not nation for some of the critical alloys used in high temperature metals. It is imperative that substitute materials be used wherever feasible. One method of doing this is by ceramic coating of important high temperature components.

8. "Hot Parts" Manufactured by Mass Production Methods **258**

BY B. A. WILLSEY

A complete discussion of the aft frame production line at Solar Aircraft Company. Of interest is the description of a new Ex-Cell-O machine. The Solar plant is organized for mass production and is patterned after Detroit mass production techniques.

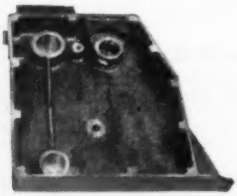
9, 9a, 9b, 9c, 9d. Special Machines Produce Components of Jet Engines

BY M. BRYAN BAKER

Hundreds of machines have been specifically developed for machining jet components and these have been analyzed and described, as much as space allowed. No standard machines have been covered because there are hundreds of thousands of standards and again space would not permit full mention. For this reason only the specials are discussed.

BICKFORD SAVES 17% WHILE speeding schedules on Skysweepers

Photos courtesy of American Machine & Foundry Company.

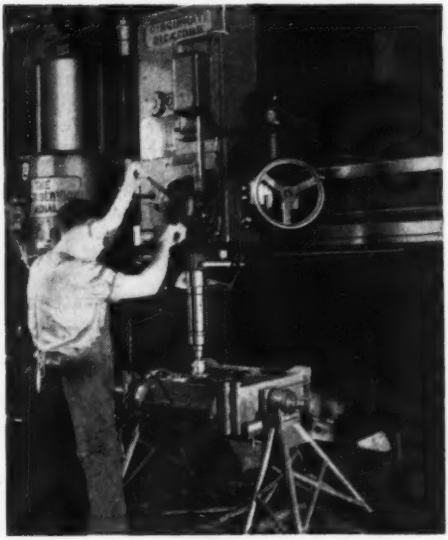


Drilling operations are performed on right and left-hand housings (steel weldments) of the U. S. Army's anti-aircraft "Skysweeper". Time was cut from 3 hours to 2½ hours, and accuracy of bore held within .0006".

The American Machine & Foundry Company states—"We like this machine not only for its performance and ease of handling but because of its flexibility of control, power and ability to stand abuse as well."

This Cincinnati Bickford Super Service Radial effected a 17% saving and speeded schedules. The machine is used to drill and tap, rough bore, finish bore, and ream.

Write for Booklet R-29



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AS THE *Editor* SEES IT

WHY A JET POWER ISSUE?

At one of the editorial board meetings last summer (see masthead, page 5) the subject of jets slipped unobtrusively into the conversation and in spite of efforts to get it ejected, made itself at home and dominated the meeting. Somebody wanted to know what made jets go; another had seen some special machines for grinding blades but wasn't quite sure what, specifically, blades were for; hot parts and cold parts of jet engines were mixed up; there was considerable knowledge of the new metals but not in relation to jet parts. Someone finally summed it up by saying, "We'd be in a pretty mess if we had to make them tomorrow!"

The consensus of opinion: The general body of metalworking executives, those not now engaged in jet or jet component manufacturing, ought to know more about the subject, about the metals, the cutting tools, the special machines that have been invented for the machining of jet parts.

Ought to do something about that, the editorial board said.

How it ought to be done was discussed at the next meeting of the board, who were unanimous in their approval of devoting an entire issue to the subject of jet power. They were also agreed on the basic content of such a jet power issue.

This issue is roughly divided into five sections: jets and their components; the new materials and the machining of them; latest developments in cutting tools as related to the machining of high alloy metals; shop shots and a manufacturing story; the special machines developed for the machining of jet components.

The metals article was prepared by Messrs. Goldberg and Hanzlick of Westinghouse, who have done quite a bit of research on the subject. The cutting tool article is the work of Mr. Lucht of Carboloy, who spent Thanksgiving putting the final touches on the machinability chart.

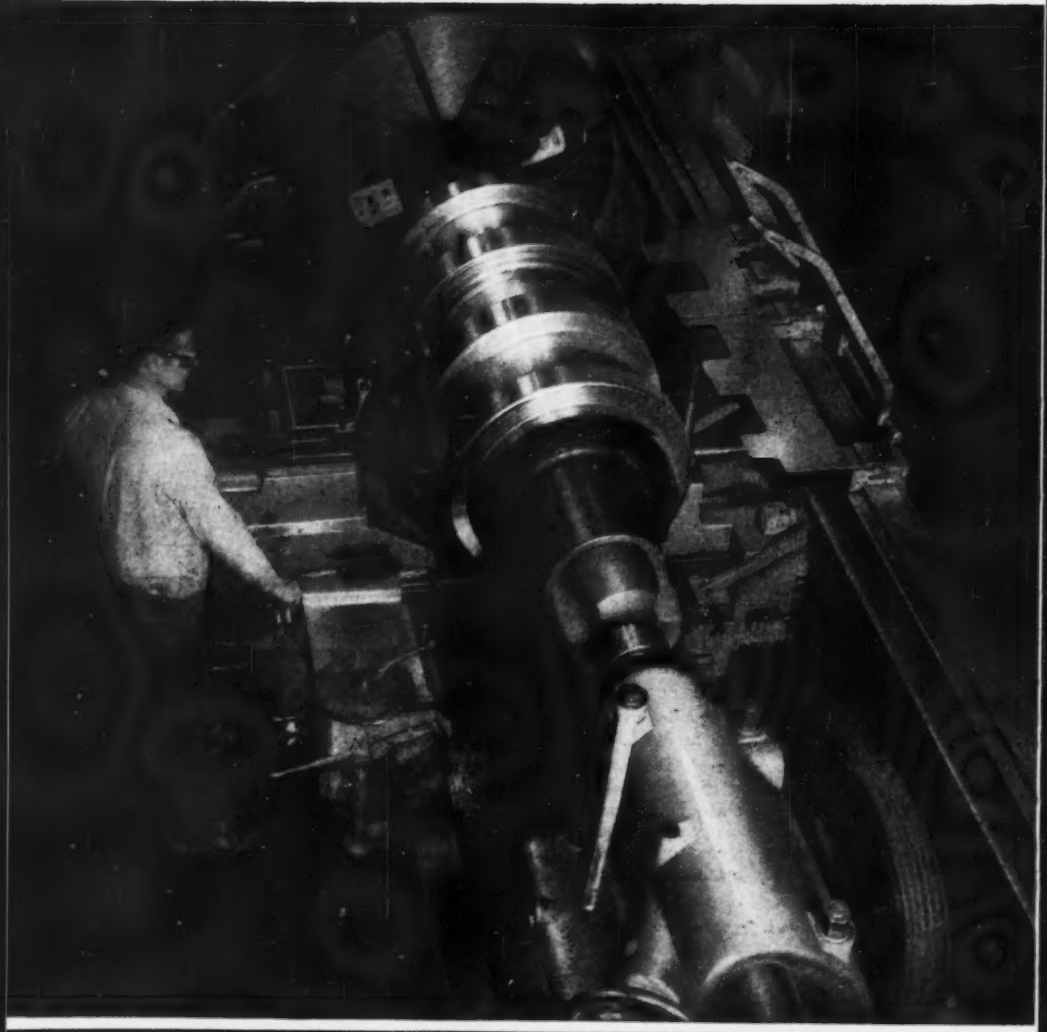
Solar and Ryan furnished the manufacturing articles as well as the material on ceramic coating. Shop shots were gathered from here and there. The operation of jets and their parts, as well as the material on special machines was prepared by the staff.

The board judged in favor of discussing only special machines because this field could probably be covered adequately by one issue; standard machines could not be discussed with justice in one issue because of the enormous variety and types of machines in use, only the surface could be scratched in a discussion of standard machines. For that reason the machine section of this issue is devoted exclusively to special machines, with apologies to the thousands of standard machines which are performing heroically on the lines of the various jet manufacturers.

Even as this issue is going to press we can see how improvements could have been made: this should have been stressed; that should have been included; why did we not treat this more fully. But as in all matters, it is easier to look over one's shoulder and reflect on what should have been done. However, though mindful of our omissions and the shortcomings of this issue, for which we blame human frailty, we hope the subject of jets, their components, and machining techniques will be clearer in the minds of production executives who may be called upon tomorrow to manufacture jet parts.

William F. Schleicher

LeBlond Lathe eases cost squeeze ...on rolls that



A set of Shape rolls of 30½" dia. x 51" body cast alloy semi-steel are turned to .005" tolerance in 9¼ hours on this 50" LeBlond Roll Contouring Lathe. Set-up time ¼ hour. Clamped-on and brazed-on carbide tips are used at 42 rpm, .040 ipr feed. Conventional roll lathe took 245 hours for the same set of rolls.

squeeze channels from blooms

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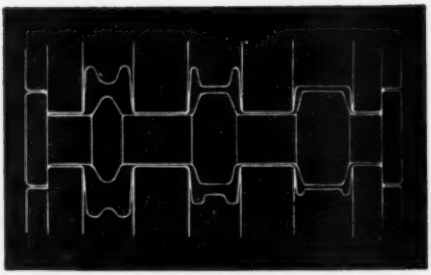

Typical roughing rolls for 8" channel

Every day at U. S. Steel's Clairton Works, Clairton, Pa., miles of "hotter-than-orange" steel are squeezed through the passes of rolls like these for reduction, elongation, shaping. They come out as finished structural steel for the "jungle-gym" frameworks of modern buildings. Turning these costly shape rolls with their steep-angle contours used to keep a lathe running *245 hours on a set of roughing rolls* at U. S. Steel. Tool life was short and the job required highly skilled operators. Stepped-up schedules called for a new solution to this tough-nut production problem.

A LeBlond 50" Roll Contouring Lathe, as recommended by Pittsburgh Distributor, Barney Machinery Co., immediately slashed the 245-hour turning time by an astonishing 61.7%. Now U. S. Steel *saves 151 hours on one set of roughing rolls*—more than enough time to turn out two more just like it. Tool life is greatly improved and less experienced operators can handle the work.

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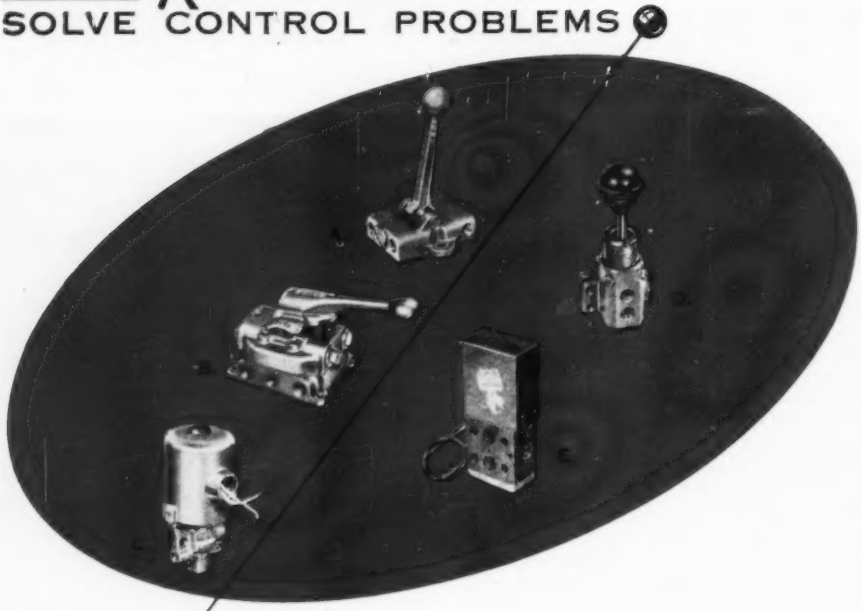

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LAST MINUTE WASHINGTON NEWS

★★★

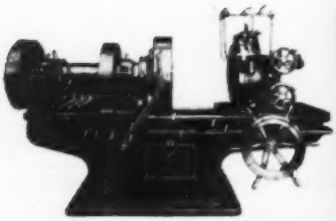
by Arnold Kruckman

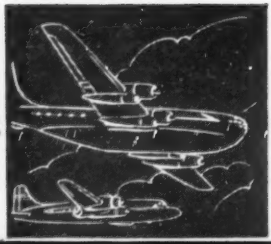
Washington Correspondent

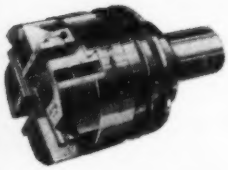
Air Force people say their big problem in planning for the extension of the use of jets is fuel, both kerosene and gasoline base; major studies are directed at getting more fuel range effectiveness. Air Force people aiming at new designs to conserve fuel, new formulae for more effective fuel; also seeking how, in government institutions and in civilian plants, atomic power may be used to fuel jets.

Apparently there are far-reaching revolutions ahead in the design of jet planes. One of the big airplane producers on the West Coast has been working hard to produce a commercial jet plane that they expect will be actually placed in service sometime next year. The Air Force is interested for MAT, round-the-world passenger and cargo service.

Incidentally, all the Services have had a live interest in a book just issued entitled "Flying Saucers Have Landed," written by Desmond Leslie and George Adamski. It is a joint American and British product. Adamski is a Californian, and Leslie is an Englishman. The book is published by a British concern, and has already sold in excess of 50,000 copies, although it has only been on the market about sixty days. It is a recitation of the experience of George Adamski who makes his headquarters at Polomar, the great astronomical center in southern California, and who, in the book, reports a contact with a flying saucer. His experience is confirmed by the affidavits of six reputable citizens of the area who witnessed the incident. Adamski's discussion, and the very exhaustive survey of the whole past history of so-called space ships by the Britisher Desmond Leslie, have led a group of scientists to make a special study of other power sources. The Services are naturally interested, in a cautious way, in what is being done and in the results that may be obtained. Apparently power, propulsion, is now of greater interest to the Air Force, and other military services, than are the actual designs of the aircraft themselves. The trend is to find power that will greatly increase flying range. There is some interest in the effort to develop propulsion from the electro-magnetic field.







LANDIS THREADS

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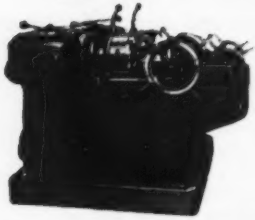

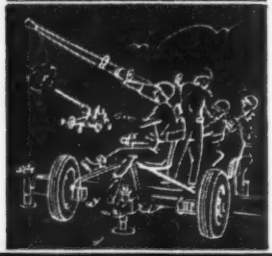

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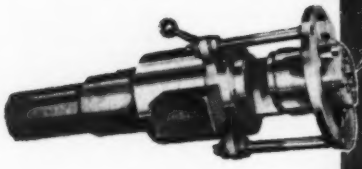

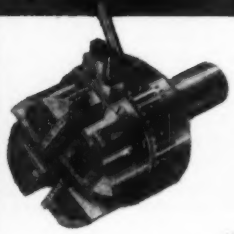

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Most informed people in Washington regard talk about cut-backs, at this time, as without much foundation. The budget cut is of course already in effect, but will not be perceptible until months ahead. At present there is no sign apparent of cut-back in equipment. There is an active plan for personnel cut-backs. This will, of course, first hit the civilian employees, and then may affect those in uniform. We are told here that most suggestions out in the country, intimating cut-backs, originate from separate and very infrequent model changes, with resulting stretch-outs.

Various agencies, after protests from two Small Business committees, took steps to make possible the free supply of nickel to practically all types of contractors. Columbite and tantalite products, used as columbium and tantalum, both in aircraft and in machine tools, have been made more plentiful by foreign sources, the Belgian Congo, Portugal, British Malaya and Nigeria. They are imported by three companies, and it is stated by the Bureau of Mines that during the first nine months of 1953 imports were 50% higher than they were during all of 1952. Columbium is one of the key alloying materials used in producing steel suitable for jet engines, and other requirements where the steel is subjected to temperatures of 1500° F., and more.

Department of Commerce, also following protests by the Senate Small Business Committee, announced that during the fourth quarter of the year it will ease controls on iron and steel scrap. Mine operators complained to the Small Business committees that imports of lead and zinc drove the price down 41% below the ceiling established under price controls. They said that in 1952 the United States needed only 225,000 tons of zinc from foreign countries and that actually the Government permitted the import of 565,000 tons. Mine operators declared this was dumping on American markets, and was driving some domestic producers into bankruptcy, causing distress, unemployment and very serious economic disturbances in many sections of the United States.

From the Senate Small Business Committee comes word that United States primary aluminum production has been boosted from 1,257,000,000 pounds to 2,500,000,000 pounds at the end of 1953. The statement is made that current expansion, scheduled for 1954, would increase the annual output to 3 billion pounds. Forty-one major representatives of the same number of principal industries of the United States met in New York recently. Six saw better times; seven felt there would be no changes; eight looked for virtually the same business as they had been doing; three predicted that the dollar volume would be off, but that the production volume would be higher; fourteen foresaw a decline in business ranging from 2% to 15%; two were certain the decline would be from 20% to 25%; and one asserted that the decline would be considerably over 25%. The automobile industry predicts it will produce 6 million units in 1954 as compared with 7.4 million units in 1953, a decline of 13%. However, they point out that this will be the third biggest year in its history. In 1929 the production record was 5.3 million units. The fuel people say their business this year is an all-

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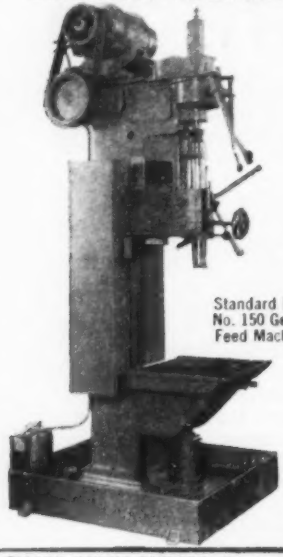

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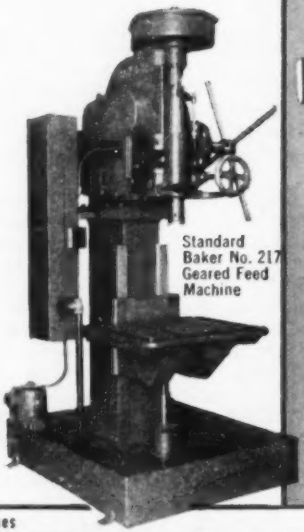

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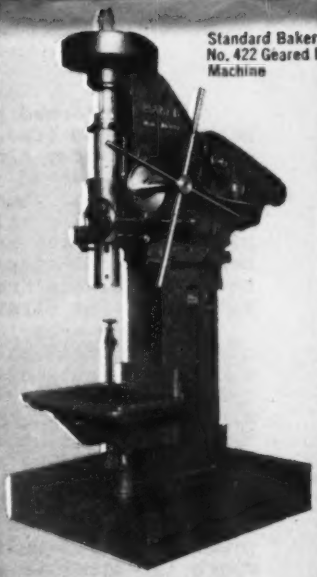

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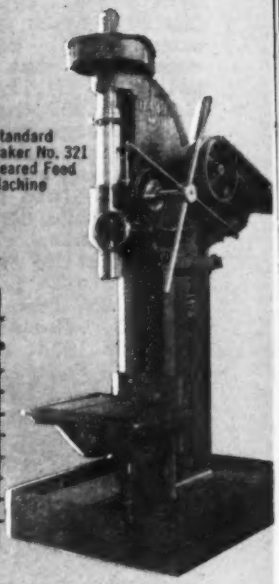

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2. Max. H. P. Motor used	7½	7½"	10	15	20
3. Distance center of Spindle to Frame (Gap)*	11"	11"	12¼"	12¼"	12¼"
4. Maximum Spindle Travel	11"	11"	12"	16"	16"
5. Spindle—Outside Dia. splined driving end	1¼"	1¼"	2"	2-13/16"	3¼"
6. Dia. of Spindle Sleeve	2¼"	2.750"	3¼"	4¼"	5¼"
7. Dia. of Spindle Nose	2.975	2.975"	.3225	4.225"	5.225
8. Morse Taper in Spindle as standard	No. 4	No. 4	No. 5	No. 5	No. 6
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time record totaling $34.7 billion; and that next year there will be a decline of from 2% to 3%. However, both automobile producers and fuel people agree that rough times are ahead for automobile dealers. They expect many of the old timers to drop out. Airplane engine production is still climbing, and may be expected to continue to climb well into 1954. The Air Force is to be expanded to 120 wings in 1954, and is to be built up to 127 wings in 1957.

In the Small Business Administration, banks and allied financial interests were opposed to a policy which would enable SBA to make direct loans to small business for business purposes. They had no objection to certain types of disaster loans, and other loans that banks did not care to handle. Apparently they had the sympathy of the Secretary of Commerce and Secretary of Treasury, who are said to have compelled Administrator William D. Mitchell to agree.

The situation was extremely difficult for Mitchell, a small businessman from Denver. Finally the Senate Small Business Committee came out flatly and made public announcement that it would hold hearings to probe into the indifference of SBA towards small businessmen in making the loans for which funds had been provided. This apparently was the first time that the White House became aware of the fact that there was a great deal of turmoil about the question throughout the country. President Eisenhower, after the fashion familiar to those who were on his staff abroad, directed the administrator to resign. Wendell B. Barnes, the general counsel of SBA, was made acting administrator.

The Small Business Administration's Loan Policy Board quickly turned about face, and late in November issued a revised policy statement. The acting administrator outlined criteria which are intended to guide the Agency's loan policy in the future. Mr. Barnes said, in a revised policy statement:

"This revision is directed at making crystal clear that -- except for those few categories of business not eligible for loans--any small business enterprise with a good management record and able to give reasonable assurance or repayment is now eligible to apply for a business loan.

"In other words, the Government is granting no preference as between types of American small business in applying for financial assistance. All can expect to have their applications considered by SBA on an equal basis . . . primary consideration will be given to the applicant's character, credit record and business ability."

The Royal Canadian Navy is purchasing F2H3 Banshee all-weather jet fighter aircraft from the United States Navy to equip carrier-borne fighter squadrons.

The twin-engine Banshee jets will replace the propeller-driven Sea Fury Fighters now in use in RCN. The Navy's first jet squadron will not fly from HMCS Magnificent but will be embarked in the new Canadian aircraft carrier to be named HMCS Bonaventure, now building in the United Kingdom.

The Bonaventure will be equipped with a catapault which will enable the jets to launch down or cross-wind, if necessary.

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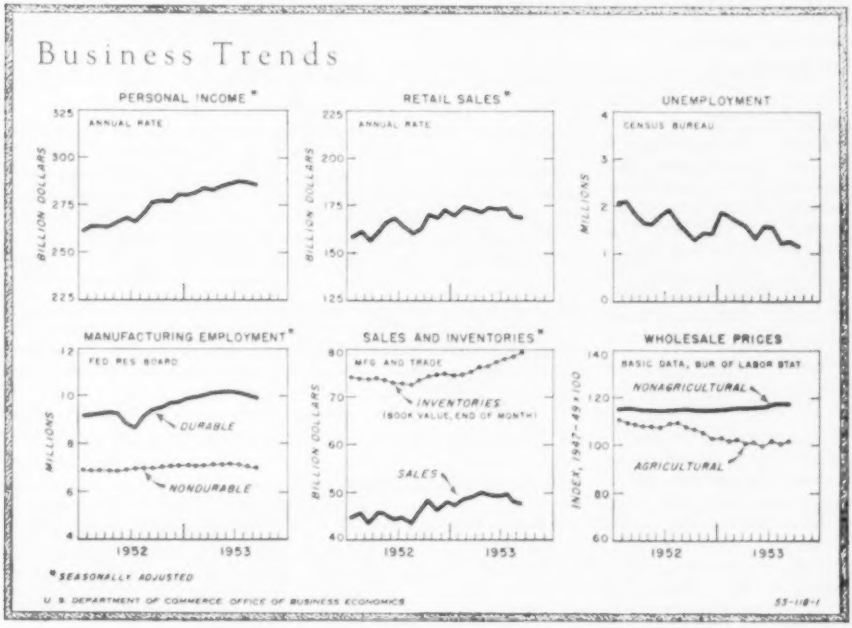
How's BUSINESS ?

Small Business

"SBA's lending program will not compete with private banks and lending institutions, but there are cases, particularly in the area of so-called 'long-term' credit, where because of legal and other restrictions banks cannot meet an applicant's full credit need." So said Wendell B. Barnes, the general counsel of SBA who was made administrator after Mitchell's resignation. (For further information on the Mitchell resignation see Arnold Kruckman's Last Minute Washington News, this issue.)

SBA is currently supplying information to 16,000 banks about the importance of the contribution banks can make by participating with SBA in making loans to meet the special requirements of small business. The House Small Business Committee points out that in two months of operation under the former policy, SBA had approved two loans totaling $78,000 to small defense contractors. And it emphasizes the policy revision is in line with recommendations presented by Congress to SBA and the agencies represented in the Loan Policy Committee. It emphasizes these recommendations have been strongly supported in the testimony of more than 100 small business representatives appearing before Congressional committees.

Under the new loan policy, among the



first to be announced was the loan to a Texas tool and machine company. The loan of $25,000 was through Texas bank in accordance with an SBA agreement.

The Senate Small Business Committee, the last day of November, revealed that the Office of Defense Mobilization asked SBA for help in determining whether qualified small machine tool shops should become eligible for tax amortization certificates. Acting Administrator Barnes said, "Considerable difficulty has been experienced in properly evaluating applications for Certificates of Necessity by these small concerns. When so classified, many companies are denied tax amortization on the grounds that there are no shortages of shop capacity. Actually, many of these cases are meritorious in that, as subcontractors, or as prime contractors, these concerns may be production shops providing high precision parts." In the future, it was determined, such cases would be referred by ODM to SBA for careful screening and evaluation.

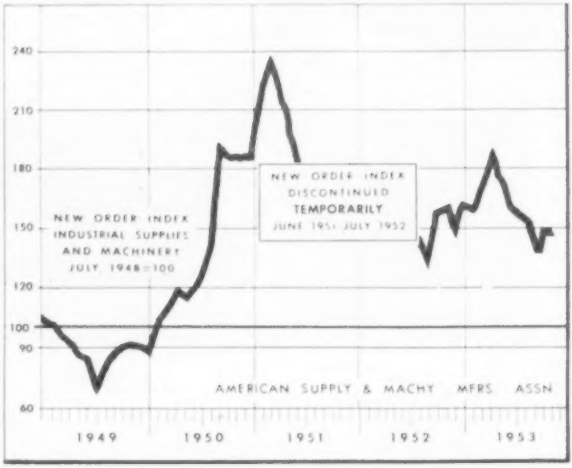
SBA has joined General Services Administration to bring complete information about pending Government purchases of civilian-type goods to small business concerns. The two agencies have arranged a full interchange of information so that field representatives of either agency will be able to tell business concerns what GSA is buying and what SBA is doing to assist small firms. The agencies plan for the future to house the information facilities of both under one roof. GSA operates business service centers in eleven cities. These maintain for public inspection copies of all current bid invitations, and essential general information. SBA has thirty field offices across the country in local areas.

Under the program announced, GSA will advise SBA of current bidding also on a regional basis, for example: The GSA office in Denver will supply SBA representatives in the Rocky Mountain area with bid information and other basic facts. SBA field offices will make surveys and make recommendations as to the competency of

Industrial Supplies and Machinery

The new order index to industrial supplies and machinery, as maintained by the American Supply and Machinery Manufacturers' Association, shows a slight decline for October. The index figure for that month is 146.0, which is 4.6 under the September figure, but 46% above the base month of July, 1948.

The October index of 146 compares with 158.4 for October, 1952.



The index is based on the dollar-volume of orders industrial distributors place with contributing members of the American Supply & Machinery Manufacturers' Association. The distributors' customers are mainly manufacturing plants. Therefore, the ASMMA order index tends to anticipate changes in industrial production. The slight decline in the new order index is in harmony with the minor reduction in industrial production as revealed by the Federal Reserve index, which was 236 for September (preliminary calculation), 5 points below the high of 241 for June, 1953.

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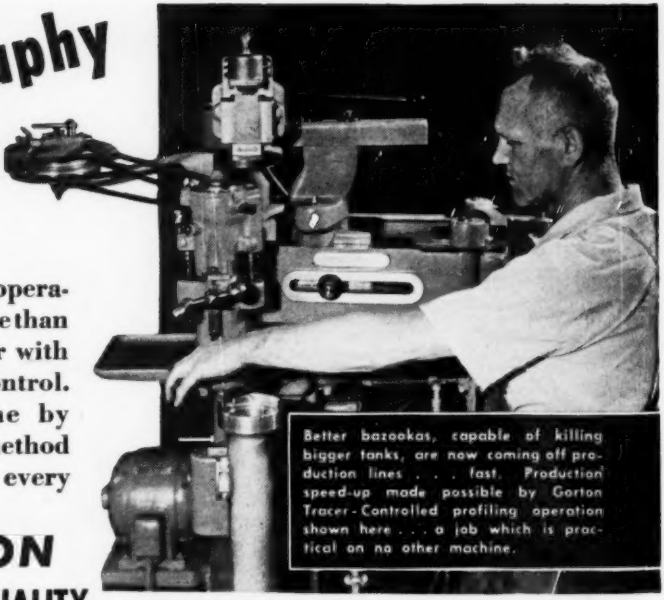

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HOLDING FIXTURE: Pneumatic-operated internal expanding type

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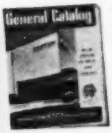

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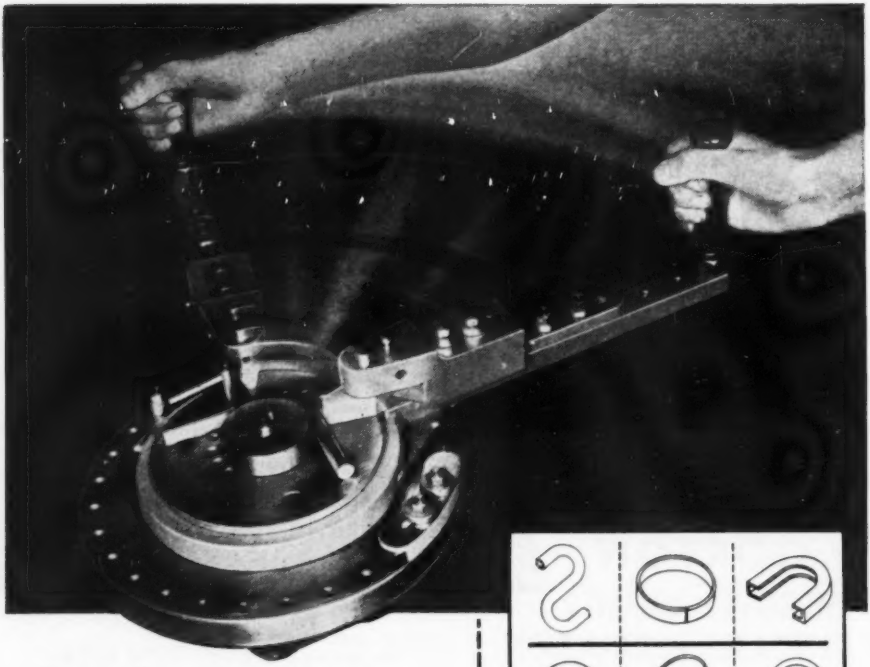

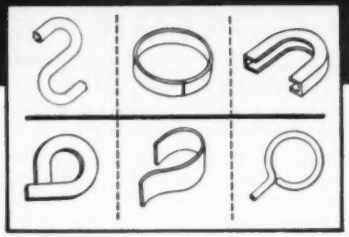

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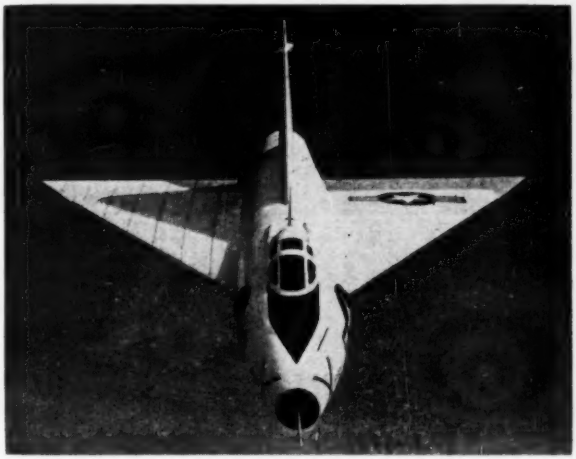
Machine Tools Down

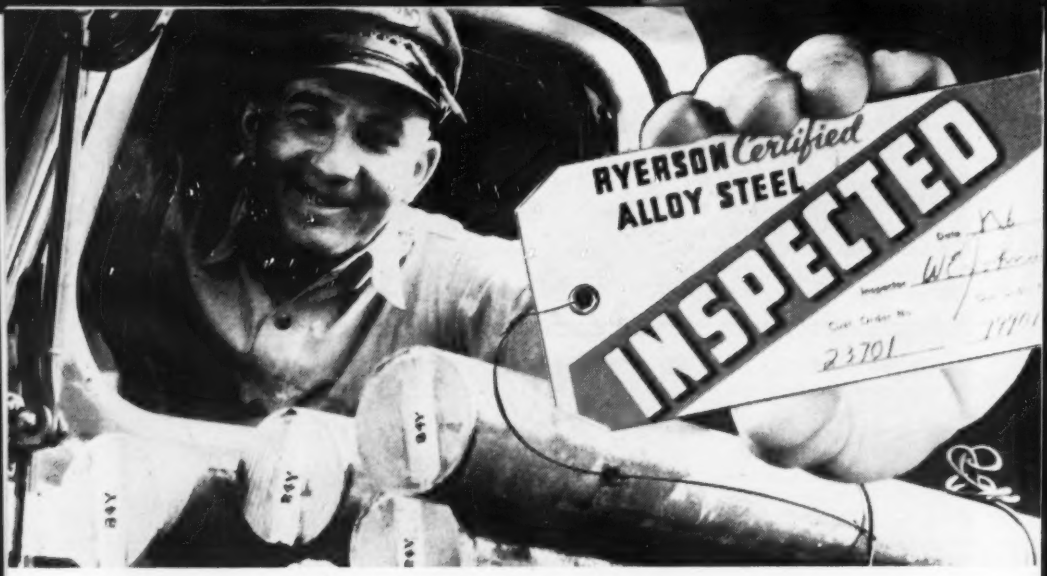
October was one of the poorest months for machine tool builders since June, 1950. October was down approximately 11% from September, and 17% from October, 1952. New orders placed in October amounted to $59 million. Cancellations amounted to 20% of last month's new business.

The National Machine Tool Builders in its monthly report said unfilled orders of the industry have declined to a little over 6½ months. At the peak of the boom the backlog was equal to 23½ months.



Convair's XF-92A Research Interceptor, which pioneered the world trend to delta wing aircraft four years ago, in a head-on flight view. The parallel lines on wing at left are rows of wool tufts which show direction of air flow. USAF research is nearing completion and the XF-92A, forerunner of the supersonic F-102 delta wing interceptor, recently ordered into production, will soon be taken over by the National Advisory Committee for Aeronautics. The plane uses one Allison J-33-A-29 jet engine with afterburner.

A spit second after being unleashed the rockets streak far in front of the Starfier. Any one of the 24 rockets fired from the nose of the F-94C packs a punch capable of knocking down, and out, the largest bomber ever built.



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History . . . Types . . . Operations . . . Parts Of Jet Engines

By **William F. Schleicher**
Editor

THE FIRST GAS TURBINE built in the United States is generally believed to have been the work of Sanford A. Moss who used the information gained from his project as the basis for his doctor's thesis. In May of 1918 Dr. Moss supervised the building, by General Electric Company, of a supercharger for reciprocating engines, considered to be the earliest application of the gas turbine for aircraft use. While numerous gas turbines were built in Europe between 1905 and 1920 they were primarily used for driving air compressors.

The turbosupercharger and turbojet are really brothers under the skin since they both convert hot gases into mechanical work through a turbine. The main difference lies in this: The turbojet generates its own heat and converts it into thrust, while the turbosupercharger depends on the hot gases from the exhausts of a reciprocating engine and may be so installed that some jet thrust is developed as the gases are exhausted. Both types of engine drive compressors directly from

the turbine shaft; however, while the air compressed by a turbosupercharger is led back to the carburetor or the conventional engine, that of the turbojet is fed into a combustion chamber where its temperature is increased by the injection of fuel. In both types of engines the expansion of the hot gases drives the compressor (to compress more air) and the accessories. All energy remaining after this is used to produce a high velocity jet.

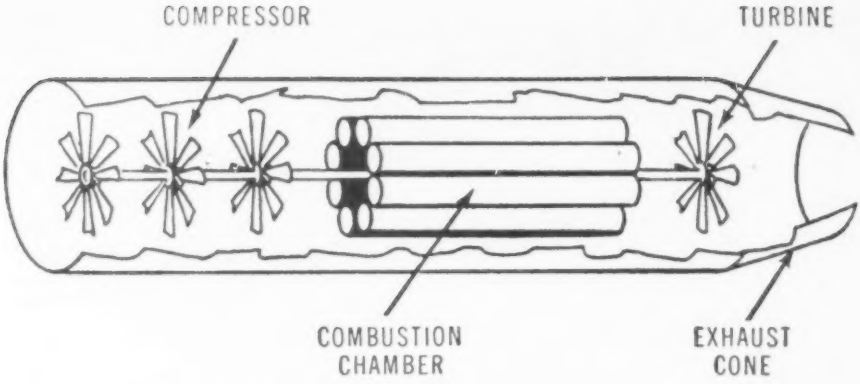
During World War II the Germans were extremely active in the gas turbine field, making the first jet-propelled aircraft flight on August 27, 1939, four days before the invasion of Poland. This was the result of many years' active research and development dating back to 1934. During the winter of 1944-45 a substantial number of jets were placed in operational use, causing considerable concern to Allied operational leaders.One drawback to the early German jets was the long take-off and landing runs which were overcome by the utilization of rocket-assists.

The Germans produced, altogether, some 1400 models Me-262. Most were lost through engine failure, inexperienced piloting and by being shot down. They had a short life and were unreliable, testimony that the planes were rushed into the air without proper testing and without further development. And yet, it must be remembered that this was but the initial jet phase of the Germans; according to General Spaatz, in 1945, if the Allies did not take Germany within six months it would be extremely difficult to send the great armadas of 1000 planes and 800 fighter escorts over Germany without huge losses. German jet know-how was growing by leaps and bounds—and so was their production.

Gas-turbine work in England followed two distinct and independent lines: the research work done on the axial compressor type by Dr. A. A. Griffith and H. Constant; and work of Air Commodore Frank Whittle on centrifugal-compressor types. The latter formed the basis of the engine produced in this country by General Electric in 1942.

Frank Whittle became actively engaged in the development of the centrifugal-compressor type of engine in 1935 when he formed a company known as Power Jets, Ltd. After the first series of tests in 1937 the Air Ministry took cognizance of the small company and placed contracts with the firm on the basis of "long term research." When Whittle proved the practicality of his designs the Air Ministry became actively interested to the point of placing contracts for a completed engine and plane. The plane was built, and on May 15, 1941, a flight was made lasting 17 minutes and doing speed runs of 2500 and 4000 feet. The engine was the Whittle engine, the plane the Gloster E28/39, and aviation circles are generally agreed that the flights undertaken by the E28/39 were the first successful airplane flights using the gas-turbine jet-propulsion engine.

The turbosupercharger had been brought to a high point of development in America during World War II, with turbojet developments receiving acceleration during 1941 when, as a result of American and English cooperation, plans for the Whittle engine were brought to this country and a team of specialists went to work at the General Electric Company to produce a turbojet, with the Bell Aircraft Corporation elected to build the plane. Exactly one year and three weeks later, in 1942, the Bell XP-59 powered by a G-E I-16 turbojet engine made a successful test flight. This was indeed a remarkable accomplishment when it is remembered that under ordinary peacetime circumstances at least ten years



1. Air enters through the inlet at the front of the engine and passes into the compressor. Here its pressure is multiplied more than five times by the hundreds of blades which pack it into smaller and smaller space. Forced into the combustion chambers, it is mixed with fuel and burned. Constant burning increases the energy of the compressed air and forces it to expand through the turbine and out through the tail cone.

The turbine, operating like a windmill, supplies the power to spin the compressor. The expanding gases, pushing their way out the rear at about 1200 miles per hour, give the plane a forward thrust, much as air forcing its way out of a rubber balloon causes the balloon to fly through the air.

would have been required to duplicate this performance.

Types of Jets

The word jet engine really means little when it is remembered that there are several types of jet engines.

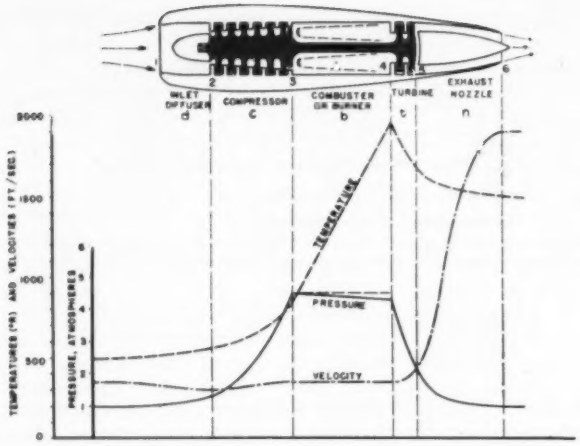
1. **Aviation Gas Turbines (turbojets)**
   Centrifugal-flow
   Axial-flow
   Turbo-prop
2. **Athodyds (Aero-Thermo-Dynamic-Duct)**
   Pulse jet
   Ram jet
3. **Rockets**
   Solid fuel
   Liquid fuel

Both the centrifugal-flow and the axial-type jet engine operate on the same general principle, with the difference of the air flow, as will be noted.

How Jets Operate

Depending upon the speed of the airplane, atmospheric air is either drawn or rammed into the inlet diffuser. This diffuser changes a part of the velocity of the air into pressure and directs the air into the compressor. The compressor then increases the pressure of the air to the point where, upon entering the combustion chamber, the air may be at a pressure of anywhere from 3 to 16 times that in the inlet diffuser, depending upon the designed compression ratio of the engine, figure 1.

In the combustion chamber, about 25 percent of the air is mixed with fuel



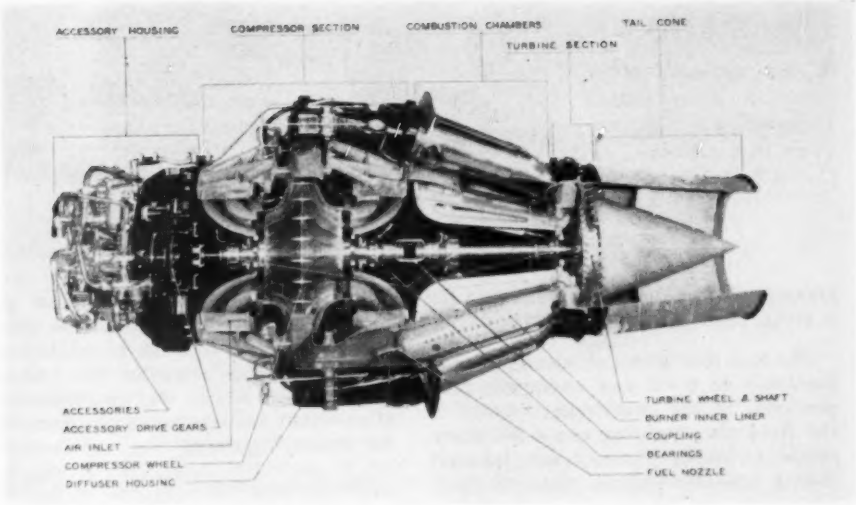
2. Basic components of a turbojet engine and the temperature, pressure and velocity of the air as it flows through the engine. Westinghouse J34 turbojet.

and the mixture ignited. The balance of the air is used to cool the metal parts of the combustion chamber and to provide sufficient turbulence for complete combustion of the fuel. The greatly expanded hot combustion gases and the cooling air are then mixed to prevent excessive temperatures at the turbine and directed by the turbine nozzles against the turbine blades. The force of the gases against the blades and the reactive force of the gases as they leave the blades impart sufficient torque for it to drive the air compressor and the engine accessories. Unlike the turbine of the turboprop engine, which tries to extract almost all of the gas energy for shaft torque, the turbojet turbine is designed to take just enough energy to do this work and thereby allow the gases to retain a maximum amount of energy for conversion into jet thrust.

To give the engine thrust—by changing the momentum of the particles of air passing through it—the gases are ejected out the rear of the engine at great speed, through an exhaust nozzle of relatively small cross-sectional area. Some of the larger turbojets currently undergoing design may eject from 100 to 400 tons of air per hour at speeds of approximately 1200 to 1400 miles per hour, figure 2.

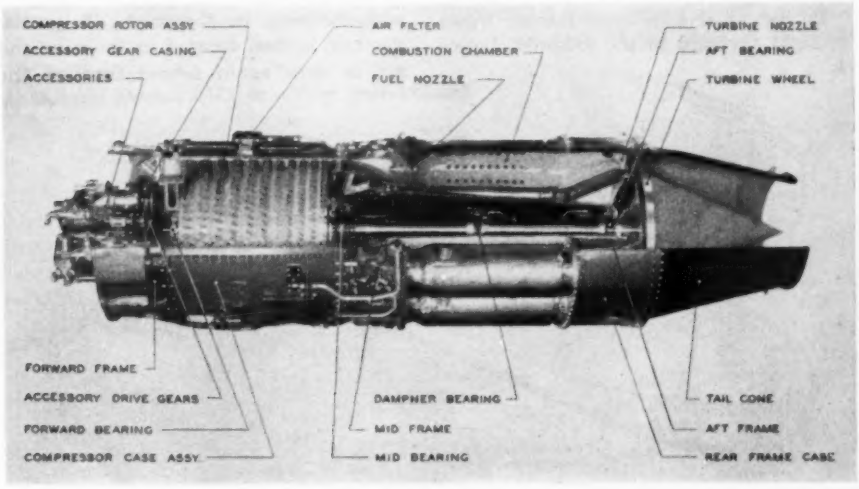
As previously stated, the thrust of a turbojet can be increased by redesigning it either to handle a greater mass of air, or to eject a given mass at a greater velocity. To handle a greater mass of air, the engine must have a larger effective air inlet area. To increase the velocity of the air being ejected, it is necessary either to expand the gases more by adding more heat, or to increase the pressure ratio of the engine.

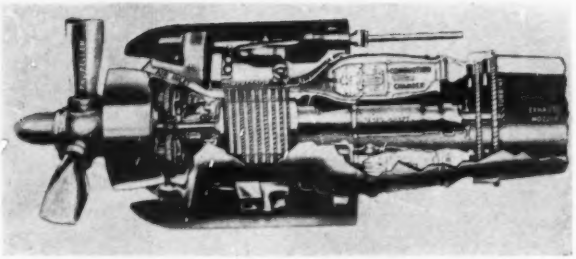
It is interesting to note that all of the new, more powerful turbojets are depending mainly upon increased mass, rather than increased jet velocities, to develop additional power. The reasons for this trend are: 1, the metals used in turbine nozzles and blades cannot withstand the greatly increased turbine temperatures that would arise by adding more heat to gain greater jet velocities; 2, wake efficiency—that percentage of the jet power that actually results in useful thrust power—increases with increased mass, and de-



3. Centrifugal-type jet engine in which the air is drawn into the diffuser, hurled centrifugally outward and into the combustion chamber where it is heated and then exhausted. Allison J33.

4. In the axial-flow type of jet engine the air flows straight through to the exhaust. Allison J35.





5. The turboprop is an axial-flow gas turbine equipped with reduction gears and a propeller. Curtiss-Wright Corporation.

creases with increased jet velocities for a given flight speed.

The fact that wake efficiency is proportional to mass and inversely proportional to the change in velocity of the fluid also explains why a jet plane needs a longer runway for take-off than a propeller-driven plane of similar power.

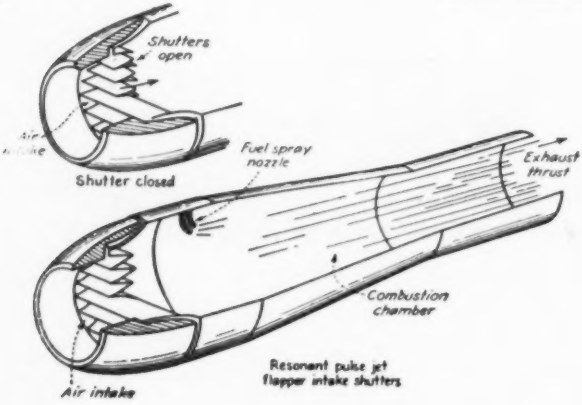
Various Types of Jets

In the centrifugal-type jet engine the impeller draws the air into the diffuser where it is hurled centrifugally outward and into the combustion chamber where it is heated and exhausted, figure 3.

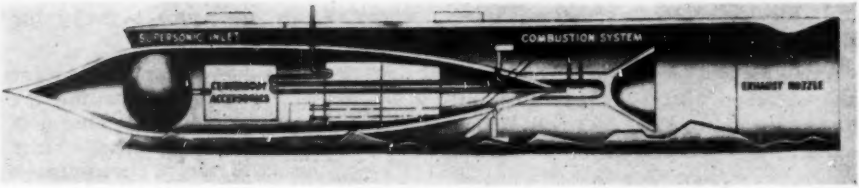
In the axial-flow type the air flows straight through to the exhaust, figure 4.

The turboprop is an axial-flow gas turbine equipped with reduction gears and a propeller. In order to rotate both compressor and propeller the turbine must use all of the energy in heated-compressed air, leaving only about 10% for thrust, figure 5.

The pulse-jet is a jet engine without a compressor or turbine wheel, figure 6. Air is sucked into the front through shutter valves and is slowed by the shape of the duct before it reaches the combustion chamber, consequently increasing its pressure. The fuel is injected continuously and is ignited by a spark plug which expands the air in all directions, closing the shutter valves and escaping in the back. A partial vacuum is thus created in the tube and air is once again forced through the



6. The pulse-jet is a jet engine without a compressor or turbine wheel. Curtiss-Wright Corporation.



7. The ram-jet is a simplified pulse-jet lacking the air valves. Curtiss-Wright Corporation.

shutter valves and the cycle is repeated many thousand times per minute setting up a loud buzzing noise.

The ram-jet is a simplified pulse because it lacks the air valves, figure 7. A ram-engine must be launched and will not operate unless air is continuously flowed past the engine. By shaping the combustion chamber air velocity is decreased, resulting in increased pressure. The exhausted air creates thrust.

The Parts of a Jet Engine

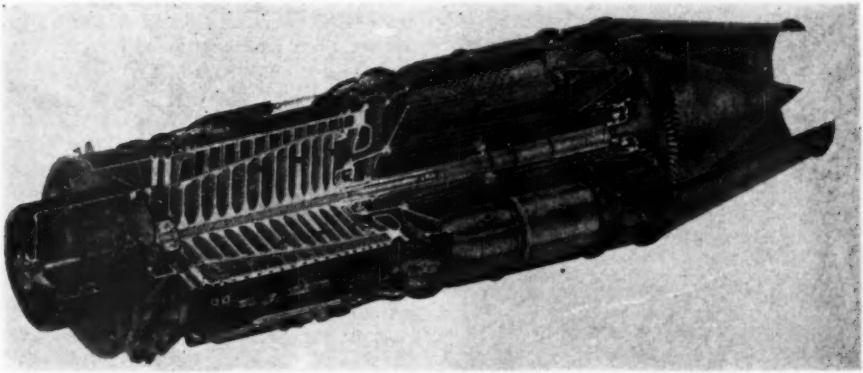
It may be advisable to analyze the various parts of jet engines and their related positions. Later chapters will discuss the components in greater detail.

Major components of a jet engine are:

1. The compressor: centrifugal-flow and axial flow
2. The diffuser
3. The air adapters
4. Combustion chambers
5. Nozzle diaphragm
6. Turbine wheel
7. Turbine buckets
8. Rotor section
9. Exhaust cone
10. Accessories section

Because we are primarily interested in machining, especially the components presenting most machining problems, our discussion will emphasize those components which will form the subject of subsequent articles: compressor, combustion, aft frame and turbine assemblies. In order to avoid confusion which would result were we to hop from one type of jet to another, and doing this without disrespect to the centrifugal-flow type, we will confine our discussion to an analysis of Gen-

8. General Electric's J47 axial-flow type turbojet.



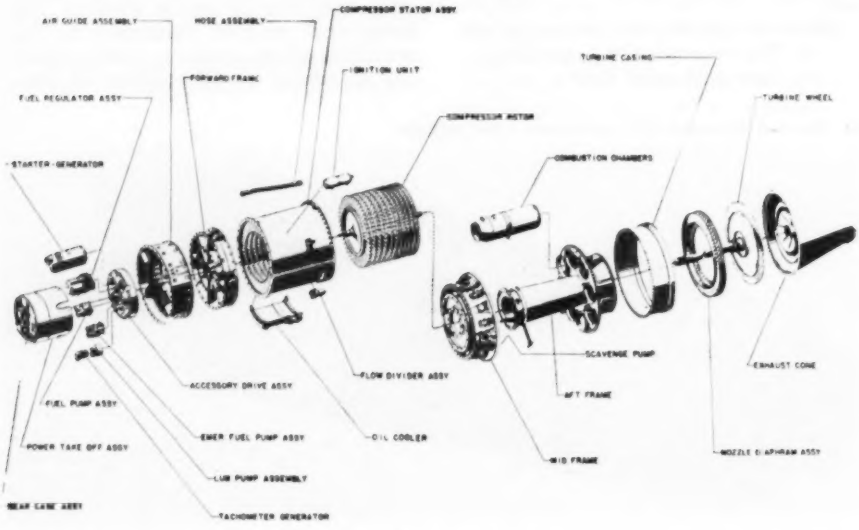
eral Electric's J47 axial-flow type, figures 8 and 9.

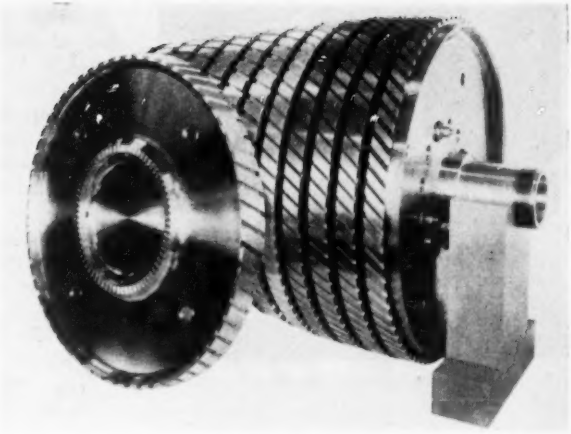
Axial-Flow Compressor: The compressor section of the J47 engine includes the rotor, stator, front frame, and rear frame. The original compressor rotor design consists of twelve wheels shrunk on a steel shaft of which the first nine are machined from 14S aluminum alloy forgings, while the last three are made from heat-treated 410 Cr. steel forgings to withstand the higher temperature of the compressed air. Precision forged compressor rotor blades are attached to the disc rim with trapezoidal-shaped dovetails. Wheel rims are connected by cylindrical spacer rings fitted under the wheel shoulders. Spacer rings between one and ten on the original compressor rotor were made of 14S aluminum; spacer rings between 10 and 12 on the original compressor rotor were made of 405 Cr. steel. Each ring is secured to an adjoining wheel rim by steel pins to carry the driving torque.

An improved type of compressor rotor construction is in production for the later J47 models, figure 10. This new curvic-coupling rotor provides a more efficient means of torque transmission and prevents circumferential shift of the wheels. Also rotor assembly and disassembly is greatly simplified. In this design the compressor wheels are splined together rather than shrunk on a shaft. The compressor wheels are geared on both sides, meshed together and secured with axial tie-bolts. Removal of the bolts permits quick disassembly of the rotor.

The cast 355 aluminum compressor casing (stator), figure 11, is horizontally split into halves, bolted together and secured at the ends to the Dow C magnesium front frame and the 355 aluminum compressor rear frame. The front and rear frames, forming the main mounting structure of the engine, are

9. The parts of the J47.



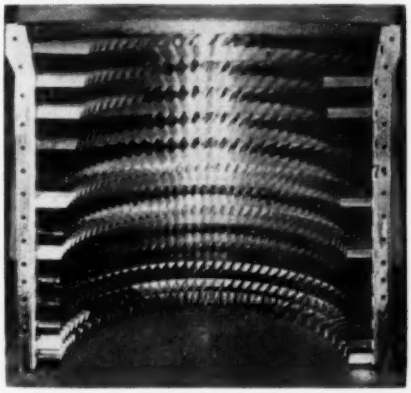


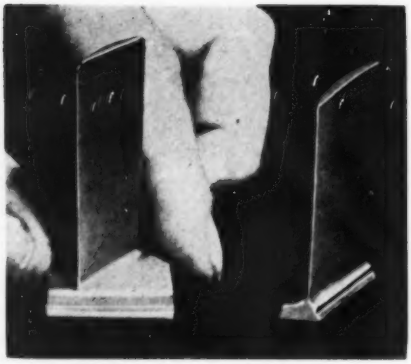
10. The improved type of rotor construction of the J47. In this design the compressor wheels are splined together rather than shrunk on a shaft.

not split. The center section of the front frame acts as a casing for the accessory drive gears and as a bearing support for the No. 1 bearing. The compressor rear frame supports the front ends of the combustion chambers and also serves as a support for the No. 2 bearing. The turbine frame bolts to the aft face of the compressor rear frame to support the turbine and exhaust sections of the engine. Four engine mounting pads, two on the horizontal and two on the vertical center lines, are located on the compressor rear frame. In order to obtain maximum producibility, four types of compressor stator blades are released for production engines: precision-forged stator blades dovetailed into split rings; sintered blades; cast blades; a new fabricated stator-blade, figure 12, is also now being used in production engines. Blades are rolled in long strips, contoured to the proper air foil section and cut to the desired length. This air foil is then welded to a base. The base is so shaped that it fills the same area as the present blade ring, eliminating the ring and an expensive manufacturing and assembly process. The fabricated stator blade provides increased resistance to vibration, gives an appreciable reduction in blade costs, and results in a critical materials saving.

Combustion Section: The eight combustion chambers, figure 13, are cy-

11. The compressor casing (stator) is horizontally split in halves, bolted together and secured at the ends to the magnesium front frame and aluminum compressor rear frame.





12. A fabricated stator blade.

lindrical in shape and are mounted circumferentially around the turbine frame. They are supported at the front end by the compressor rear frame and at the rear end by the turbine frame. Quick disconnect rings are used at the ends to facilitate disassembly. Each combustion chamber assembly consists of an outer chamber and a removable inner liner. The liner has openings to permit compressed air to enter it from the outer combustion chambers. A fuel nozzle inserted in the front of each combustion chamber supplies atomized fuel for combustion. Ignitor plugs are positioned in two of the eight chambers. During combustion some compressor air is admitted to the liner at the dome or cap; the balance of the compressor air is fed to the liner throughout its length via holes and louvers in the shell. This cools the liner and reduces the temperature of the hot gas. Burning is complete before the gases reach the turbine nozzle.

Cross ignition tubes connect the combustion chambers at their forward end. Inserted in these tubes are inner crossover tubes, linking the individual combustion inner-liners and permitting flame propagation from one chamber to the next.

Inconel transition pieces at the aft end of each chamber conduct the hot gases to the turbine nozzle diaphragm.

The aft frame, figure 13, bolted to the compressor rear frame, supports the turbine and exhaust assemblies, and also embodies the support plate to which the combustion chambers are attached. A fabricated assembly of 321 stainless steel, it utilizes internal longitudinal hat-section stiffeners.

Turbine Assembly: The J47 engine employs a single-stage, impulse-type design consisting of a turbine nozzle diaphragm and a wheel and shaft.

The turbine rotor and compressor rotor shafts are joined with a splined fit between the twelfth-stage compressor wheel and the front end of the turbine shaft. These are locked with a shaft bolt which runs through the hollow turbine rotor shaft. The turbine shaft is supported by two bearings; the No. 3 or damper bearing at the mid section of the shaft, and the No. 4 bearing at the wheel end of the shaft. The turbine wheel buckets are forged from S-816, a heat-resistant alloy, and dovetailed into the wheel rim.

The turbine wheel consists of a ring of Timken Alloy 16-25-6 stainless steel, to withstand high temperature, welded to 4340 steel hub. The front surface of the wheel is cooled by air extracted from the eighth-stage of the compressor; the rear surface is cooled by air extracted from the twelfth-stage.

The nozzle diaphragm consists of an inner and outer diaphragm ring of 321 stainless steel, between which 64 cast blades are welded to form the nozzles. Removal of the exhaust cone, turbine wheel and nozzle diaphragm for inspection or replacement, without complete engine disassembly, is a feature of this design.

Exhaust Cone: The exhaust cone provides an outlet for the exhaust gases. It is bolted to the turbine casing and

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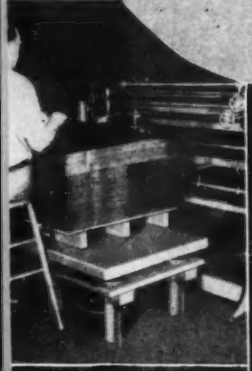

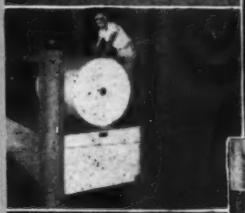

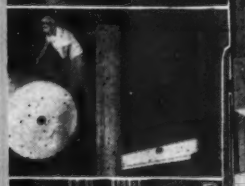

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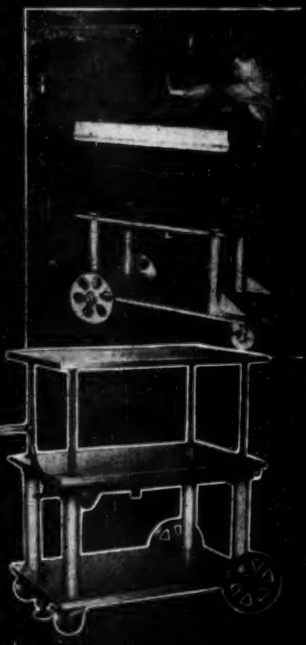

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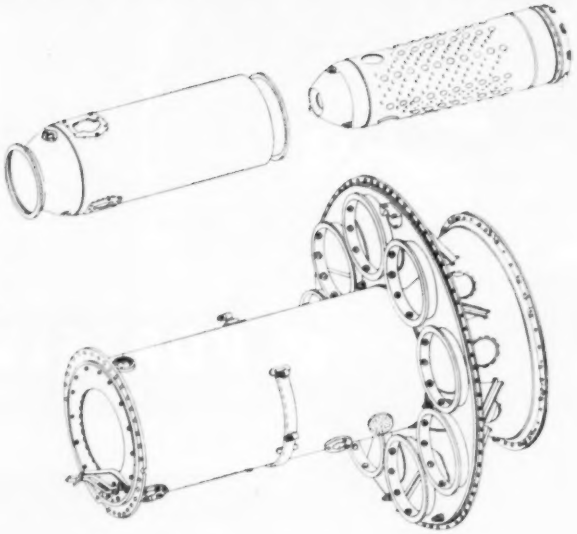

13. The aft frame which is bolted to the compressor rear frame supports the turbine and exhaust assemblies. On the bottom is the aft frame assembly; upper right shows a typical liner while the outer chamber is shown at the top left.

extends aft from the turbine wheel. An inner cone is suspended from four rods secured to the outer exhaust cone. The exhaust pipe and nozzle are supplied by the aircraft manufacturer (except in the case of the afterburner engine where burner and variable-area-jet nozzle are a part of the engine).

Afterburners: Not standard equipment on jet engines as they have been discussed here, yet an important accessory to jet engines, is the afterburner. From a tube no bigger than an elongated barrel energies are released which can virtually double the thrust of the most powerful engine.

Essentially a ram-jet engine hooked to the tail of a turbojet, an afterburner is a flaming tailpipe which feeds upon the unburned oxygen in the jet stream. In a conventional piston-type engine, air and fuel are mixed together in about a 16 to 1 ratio and rammed into the cylinders. In the turbojet, the air-fuel ratio is 60 to 1. About one-fourth of the air, or oxygen, is burned in the combustion chambers. The rest is used to dilute the mixture to keep temperatures down and to cool the engine's hot components. The oxygen in this unconsumed air of the jet stream supports the combustion of the afterburner.

On paper, an afterburner looks like an easy way to get big thrust dividends from a jet engine. You simply inject gallons of fuel into the jet stream, ignite them and enjoy the tremendous burst of speed which the escaping gases impart. Since the burning takes place downstream from the engine, no added thermal or mechanical stresses are imposed on the critical parts of this highly stressed power plant.

References

Jet Propulsion Progress, by Leslie E. Neville and Nathaniel F. Silsbee. McGraw-Hill Book Company, Inc.

Jet Aircraft Power Systems, edited by Jack

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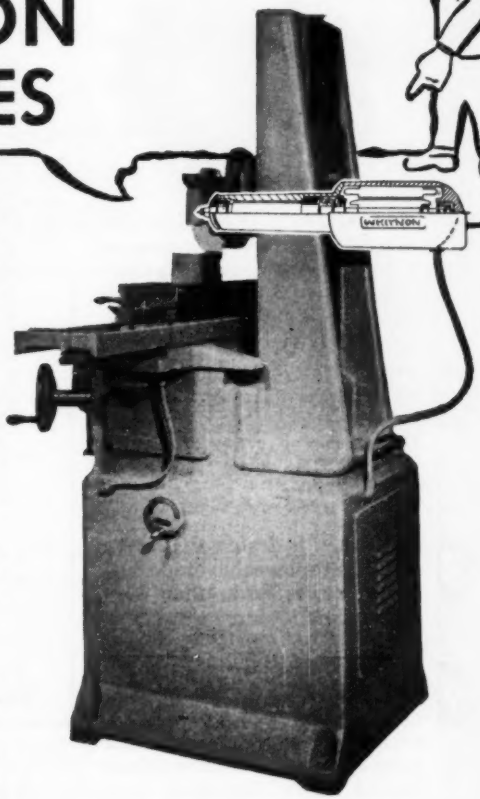

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Grateful thanks are due to the various aircraft companies, machine tool builders, accessories manufacturers, jet engine builders, and component parts producers whose cordial assistance in supplying photos, texts and technical help made this issue possible.

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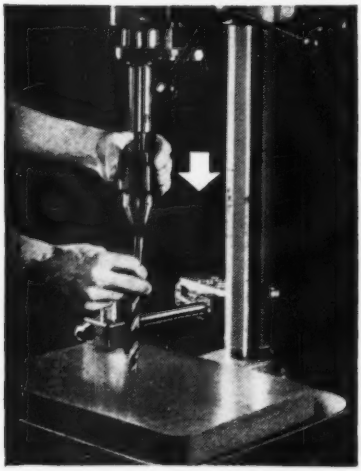

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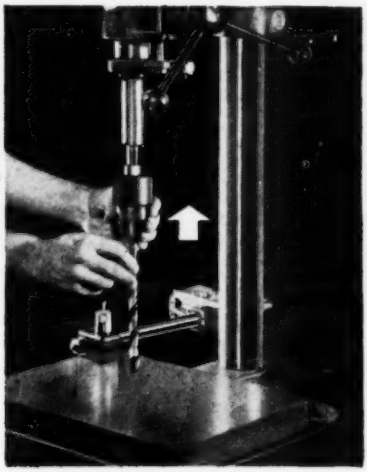

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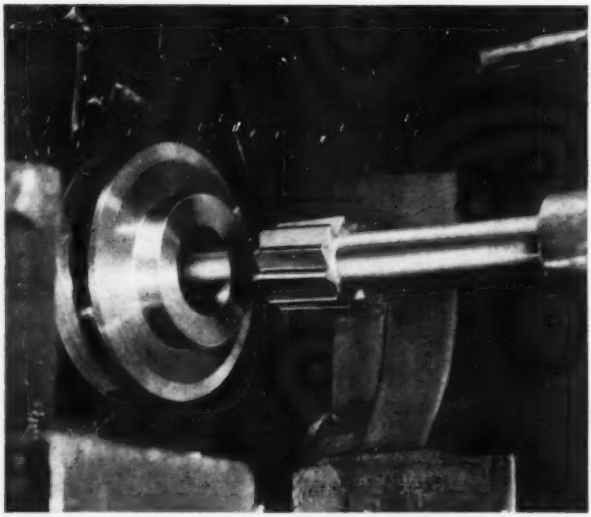

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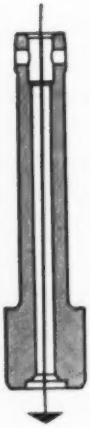

oil feed

An outstanding feature of these oil-feed reamers is that the oil feeds through the body of the reamer to flush the chips away from the cutting area. Other types of reamers tend to pack the chips in front of the reamer, increasing the chance for "pick up" which often ruins the finish and shortens the life of the tool. As the oil hits the end of the hole, it is forced back between the flutes, carrying the chips with it. Another aid to extending tool life is that the oil reaches the cutting area on jobs which could not otherwise effectively employ

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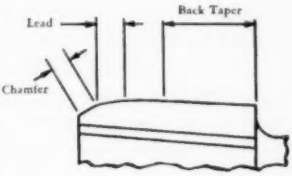
Irregular spacing is a standard feature of all Barber-Colman Oil-Feed Reamers. This type of spacing provides a smooth cutting action and fine finish and prevents the reamer from forming "welts". Thus, the design of the spacing in conjunction with the oil-feed feature allows these reamers to produce surface finishes which formerly required a secondary finishing operation. To aid in checking the reamer diameter, the flutes are spaced diametrically opposite each other so that they can be inspected with a micrometer.

cam-controlled sharpening

The profile form on the reamer flutes is important in obtaining the best finish and tool life. Following a 30° chamfer, the lead is blended into a radius and followed by a straight portion which irons out the feed marks. This combination produces exceptionally fine finishes. Also, through the use of the Barber-Colman system of sharpening, a theoretically sharp cutting edge is produced rather than a cylindrical land. The Barber-Colman system is cam-controlled so that each reamer is sharpened with exactly the same profile. These are features which are available in no other type of reamer.



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These spring-type floats hold the reamer firmly, eliminating any sagging. Its simple design, consisting of only the holder, drive pin and spring, makes it easy to operate and maintain. An opening through the center of the float allows the oil to reach the reamer. Only two floats are required to cover the complete range of sizes, although a float of extra length is available for the larger sizes. These reamers are available for diameters of .344" through 1.380".

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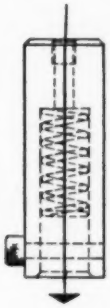

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Aircraft Gas Turbines Produced in America and Europe

By **Paul H. Wilkinson**
Editor, "Aircraft Engines of the World."

AIRCRAFT GAS TURBINES are of two basic types—centrifugal and axial. These appendages apply to the compressors of the engines, for both types have axial flow turbines. Centrifugal type engines are relatively easy to manufacture. The compressor blades are integral with the compressor impeller disc, and the only individual blades or buckets required are those for the turbine wheel. Pressure ratios aft of the compressor vary from 4:1 to 5:1, which restricts the power output of this type of engine to a maximum of about 7,000 pounds thrust if its external diameter is kept within reasonable aerodynamic limits.

Centrifugal type turbojets now in production in America comprise the Allison J33 rated at 5,200 to 6,350 pounds thrust, the Continental J69 which gives 900 pounds thrust, the Fairchild J44 of 1,000 pounds thrust, and the Pratt & Whitney J48 built under British license and rated at about 7,000 pounds thrust. In England, turbojets of this type include the De

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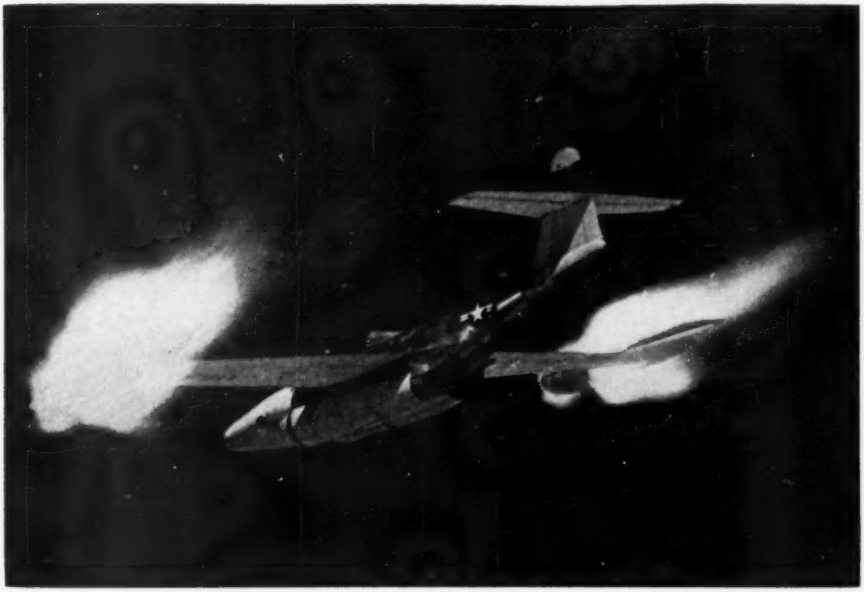
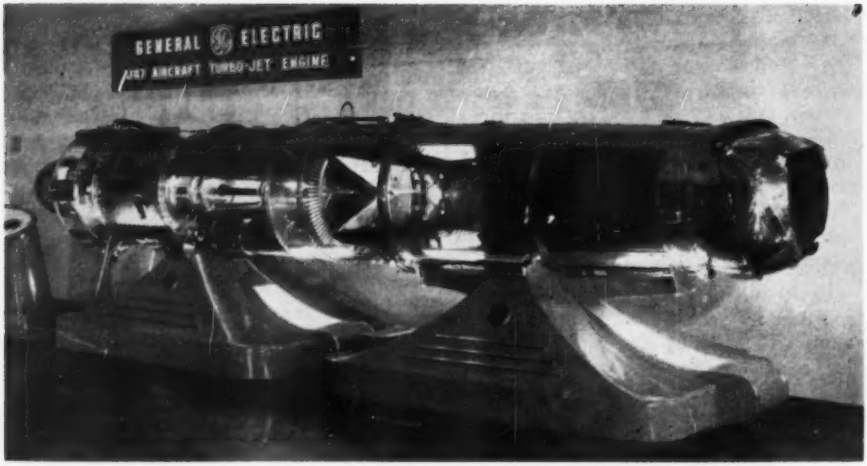
Havilland Goblin and Ghost of 3,500 and 5,000 pounds thrust, respectively; and the Rolls-Royce Derwent of 3,600 pounds thrust, Nene of 5,100 pounds thrust, and Tay of 6,250 pounds thrust. Other centrifugal type turbojets built in Belgium, France, Italy, Sweden and Switzerland—with the exception of the French Turboméca engines—are copies or adaptions of these British power plants.

Centrifugal type turboprops now in production are limited to one British engine—the Rolls-Royce Dart, which has a two-stage impeller and is rated at 1,700 equivalent shaft horsepower (shaft horsepower plus residual jet thrust). The Bristol Proteus turboprop with a combined axial and centrifugal compressor, which is rated at 4,150 equivalent shaft horsepower, is also in production in England.

Jet engines of the centrifugal type are used extensively in military and commercial aircraft. Their cost is reasonably low, judged by present-day aircraft power plant standards, and they have relatively long life. In America, centrifugal type turbojets are used in Lockheed F-80's, F-94's, and T-33's; and in Gruman F9F Panthers and Cougars. British military aircraft using them include De Havilland Vampires and Venoms, Gloster Meteors, and Vickers Supermarine Attackers. All of the British jet airliners now in service—De Havilland Comet 1's and 2's and Vickers Viscounts—are equipped with centrifugal type gas turbines. The Bristol Britannias now in order likewise are equipped with them. Where subsonic speeds suffice, centrifugal type jet engines make excellent power plants.

Axial type jet engines—so called because of the axial flow of air through their multi-stage compressor—are used

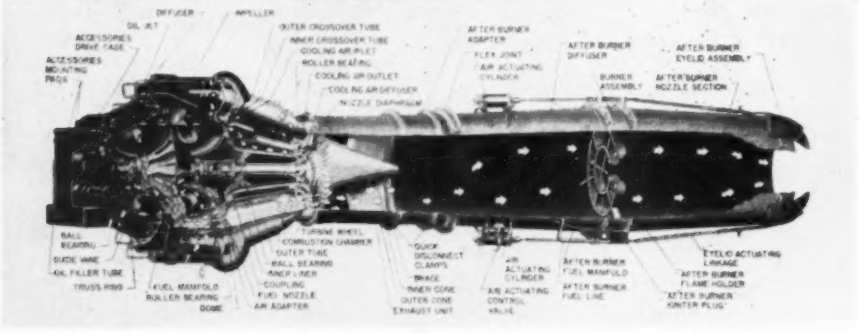




Cut-away view of General Electric J47 axial type turbojet with afterburner, in production for North American F-86D Sabre Jet interceptors. Rated at more than 7,000 pounds thrust with reheat.

where greater power and higher speeds are desired. These engines have higher pressure ratios, of 7:1 or more, which give them more air in which to burn more fuel, and develop more thrust. Some of the latest ones have "twin spool" compressors with low-pressure and high-pressure sections which result in better fuel economy. Being of relatively small external diameter, these engines are well suited for submerged wing or under-wing mounting. Production is more complicated, however, as there may be nearly two thousand rotor

Cut-away view of Allison J33 centrifugal type turbojet with afterburner, used in Lockheed F-94B Starfire fighters. Rated at 7,000 pounds thrust with reheat.



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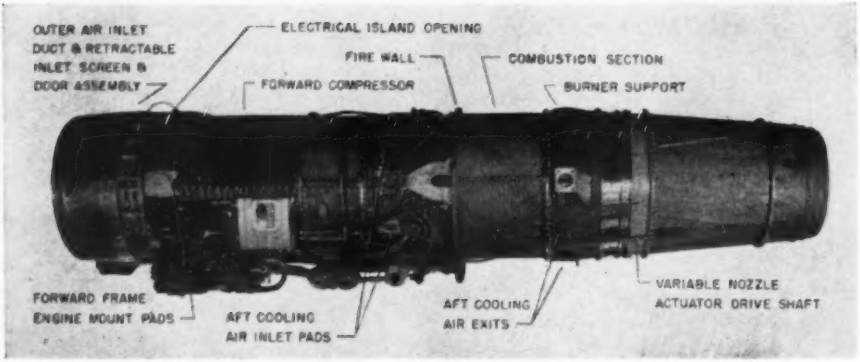
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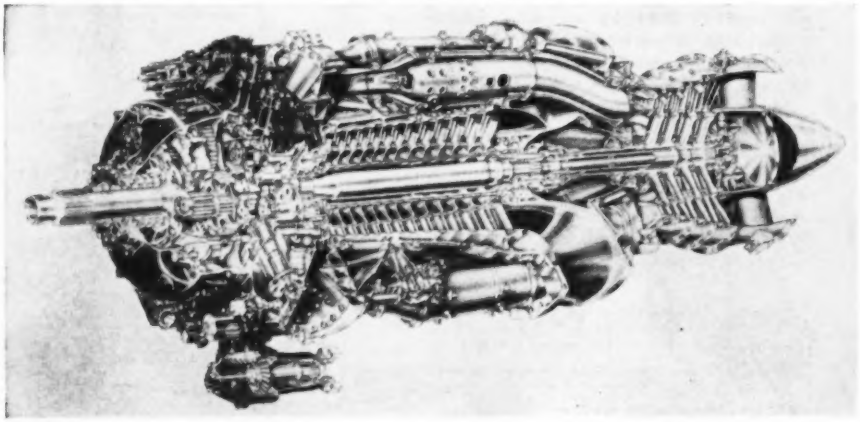
External view of Allison J71 axial type turbojet, in production for Douglas B-66 bombers and Republic F-105 fighter-bombers. Rated at 10,000 pounds thrust.

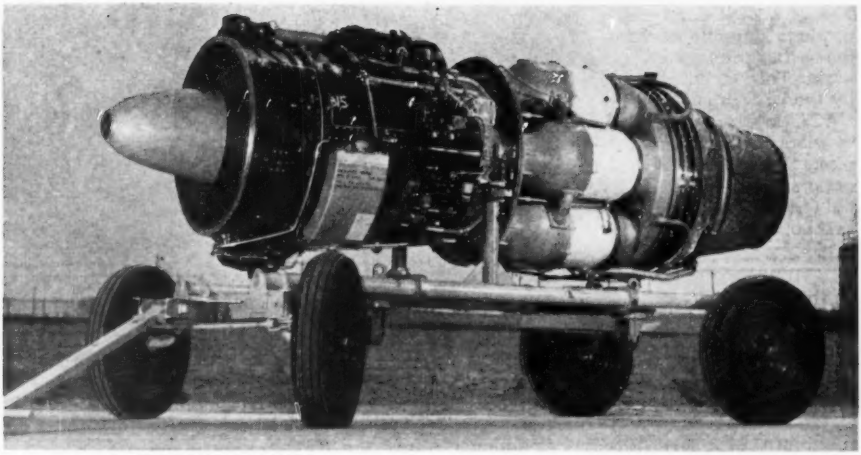
blades and stator blades of varying lengths and aerofoil sections in the compressor.

Axial type turbojets in production in America include the Allison J35 and J71 rated at 5,600 and 10,000 pounds thrust, respectively; the General Electric J47 of 5,800 pounds thrust, and J73 of 9,000 pounds thrust; the Pratt & Whitney J57 of about 10,000 pounds thrust; the Westinghouse J40 and J46 rated at about 4,000 and 8,000 pounds thrust respectively; and the Wright J65 Sapphire built under British license and rated at 7,200 pounds thrust.

In England, there are the Armstrong Siddeley Viper rated at 1,640 pounds thrust, the Bristol Olympus of 9,500 pounds thrust, and the Rolls-Royce Avon of 7,500 to 10,000 pounds thrust

Cut-away view of Bristol Proteus axial-centrifugal type turboprop, in production for Bristol Britannia airliners. Rated at 4,150 equivalent shaft horsepower.

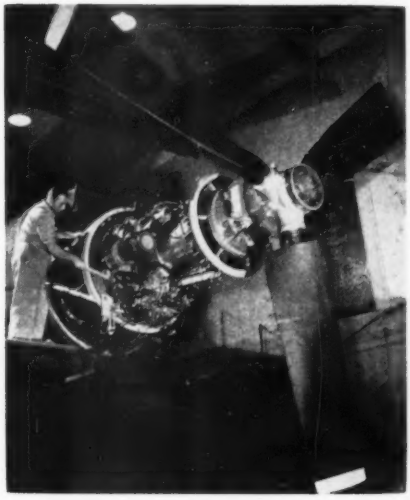




View of Avro Canada Orenda turbojet, in production for Avro Canada CF-100 all-weather fighters and Canadair Sabre 5 fighters. Rated at 6,500 pounds thrust.

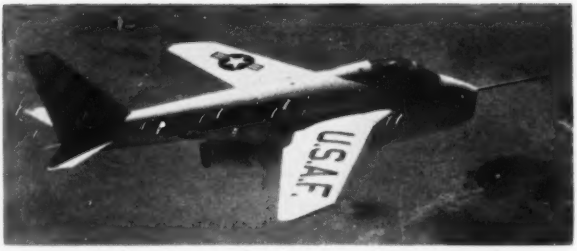
in production. Canada is manufacturing the Avro Orenda rated at 6,500 pounds thrust. Other foreign turbojets in this classification include the French S.N.E.C.M.A. Atar and Vulcain rated at 6,600 and 9,900 pounds thrust, respectively, and the STAL Dovern of 7,275 pounds thrust, built in Sweden. Axial type turbojets built in other countries—with the exception of the U.S.S.R.—are licensed from British engine companies.

Pratt & Whitney Aircraft T-34 turboprop engine.



Practically all of the larger engine manufacturers are working on axial type turbojets with considerably higher power outputs. In America, General Electric's J53, Pratt & Whitney's J75, and Wright's J67—in the 12,000 to 15,000 pounds thrust range—are under development. In England, the De Havilland Gyron of about 15,000 pounds thrust and the Rolls-Royce Conway of approximately 12,000 pounds thrust are being tested for military and commercial aircraft.

Axial type turbojets are now used in most military aircraft in production and under development. In America, practically all of the latest fighters, interceptors, fighter-bombers, and long-range bombers for the Air Force, such



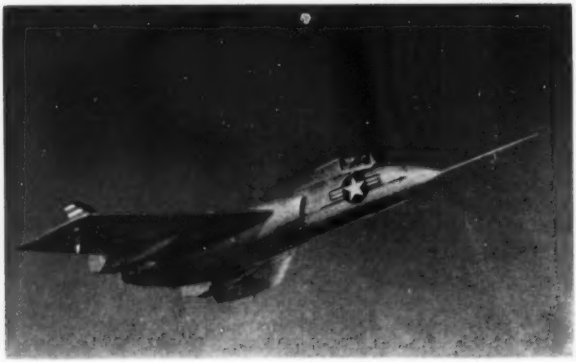
The X-5, first (and only) airplane capable of varying wing sweepback in flight. This is being used by the U. S. Air Force and NACA to study the effect of wing sweepback on airplane speed and over-all performance. The X-5 is built by Bell Aircraft Corp., Buffalo, N. Y.

as the Boeing B-47 Stratojet, the Douglas B-66, the Martin B-57A Canberra, the North American F-86 Sabre, the Northrop F-89 Scorpion, and the Republic F-84 Thunderjet and Thunderstreak, are powered with axial type turbojets. Likewise, the Navy's Chance Vought F7U Cutlass, Douglas F3D Skynight and F4D Skyray, and McDonnell F3H Demon have these sleek power plants.

The Air Force's new "100" series of supersonic interceptors and fighters—the North American F-100, the McDonnell F-101, the Convair F-102, the Republic F-103, the Lockheed F-104, and the Republic F-105—will all be equipped with high-power axial type turbojets.

In England, military aircraft of superpriority status, such as the Avro Vulcan, the English Electric Canberra, the Gloster Javelin, the Handley Page Victor, the Hawker Hunter, the Vickers Supermarine Swift, and the Vickers Valiant, have axial type power plants. This type of engine is also coming into use in Australia, Belgium, Canada, France, Holland, Italy and Sweden for their latest military aircraft. Commercial aircraft of the near future will also be powered with axial type turbojets. In America, prototypes of high-speed airliners have been designed to use them. In England, axial type turbojets are scheduled for the De Havilland Comet 3's under construction, a prototype of which is already flying.

Axial type turboprops at present are used only for military aircraft. Allison's T40 dual unit engine rated at 5,500



Chance Vought Aircraft's twin-jet F7U-3 Cutlass is the first sweptbackwing, tailless fighter to fly from a flat-top. It was designed to give the U.S. Fleet a fast shipboard fighter offering superior performance, a greater rate of climb and greater range and firepower. The Cutlass does not have a tail section but instead incorporates two vertical stabilizers and rudders at the trailing edge of the wing.

A Library of Collet and Chuck information

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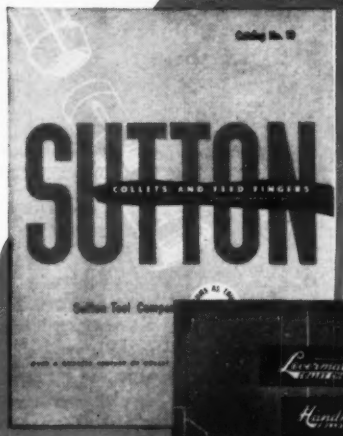

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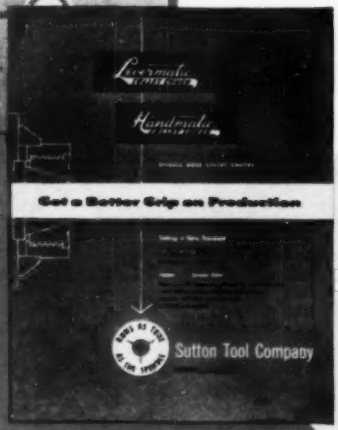

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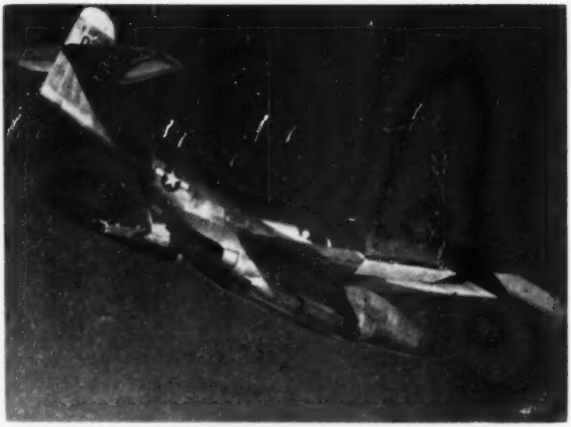

This flight photo of the U. S. Air Force Northrop Scorpion F-89, the first ever released showing the plane's "speed brakes" operating in flight, reveals the wide braking area available on the twin-jet all-weather interceptor. Known as "decelerons," these double feature surfaces act as ailerons and speed brakes. In normal flight, the jaws are closed and the controls function as ordinary ailerons. In dives, the jaws open full for braking effect.

equivalent shaft horsepower and T56 single unit engine of 3,750 equivalent shaft horsepower, and Pratt & Whitney's T34 rated at 5,700 equivalent shaft horsepower are in production in America. Armstrong Siddeley's Mamba, Double Mamba, and Python of 1,560, 3,125, and 4,125 equivalent shaft horsepower, respectively, are being manufactured in England. Napier's Eland rated at 3,000 equivalent shaft horsepower, now under test in the latter country, is for commercial aircraft including helicopters.

With regard to the jet engines of the U.S.S.R., the centrifugal RD-45 is giving about 6,000 pounds thrust in the latest MIG-15 fighters. Axial type turbojets such as the M-012 and the M-018, rated at 6,000 and 8,000 pounds thrust, respectively, are used in IL-28 attack bombers, MIG-17 night fighters, and TU-12 medium bombers. Turbojets of 10,000 pounds thrust are under development. Turboprops in production include the M-028 of 8,000 equivalent shaft horsepower, adapted from the M-018, and used in the TUG-75 long-range bomber.

Electric starters are used on most

The F9F-6 Cougar is the swept wing successor to the battle-proven Grumman Panther, the first jet to be used in combat by the U.S. Navy. The Cougar is a much faster airplane than the Panther, capable of breaking the sound barrier, yet has retained the same low landing and take-off speed. The Cougar is powered by a Pratt & Whitney jet engine.

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centrifugal type engines, and on some axial type power plants. Gas turbine type starters of from 150 to 350 horsepower are now used to bring the compressor-turbine rotary element of high pressure ratio jet engines up to firing speed. Compressed air starters are used on some Navy engines.

Thrust augmentation devices are employed on many jet engines to enable them to give more power for take-off and climb. Water injection into the compressor or combustion chambers is used for both military and commercial engines, and adds from 10 to 15 per cent to the maximum power of the engine. Afterburners attached to the turbine outlets of high power military engines are standard equipment on fighters and interceptors to improve their take-off, climb and combat performance. Functioning as a ramjet, the

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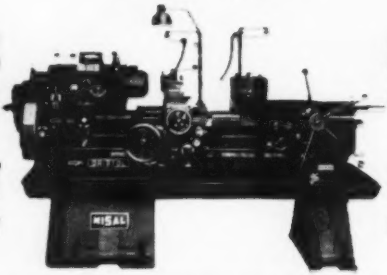

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afterburner adds about 30 per cent to the engine's thrust when static, and about doubles its thrust when the aircraft is flying at full speed. Fuel consumption is doubled with the afterburner on, however, and its noise is terrific, so this reheat device is not used on commercial engines. Thrust retardation devices, or "spoilers," to provide reverse engine thrust when landing, are under development.

Military jet engines, such as the Allison J33 and J35, and the General Electric J47, recently have been approved for 1,200 hours between overhauls. In commercial service, the De Havilland Ghost used on the Comet 1 and 2 has been cleared for 600 hours, and is expected to be approved soon for 750 hours between overhauls. When the mileage flown by the aircraft is taken into consideration, it is evident that the overhaul periods for jet engines are now about on a par with those for piston engines.

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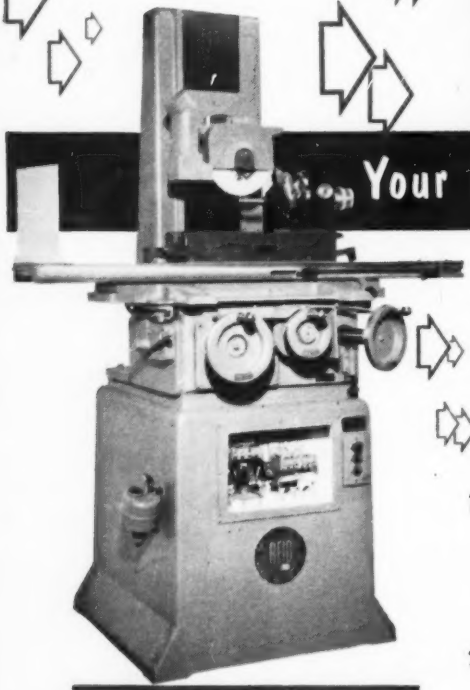

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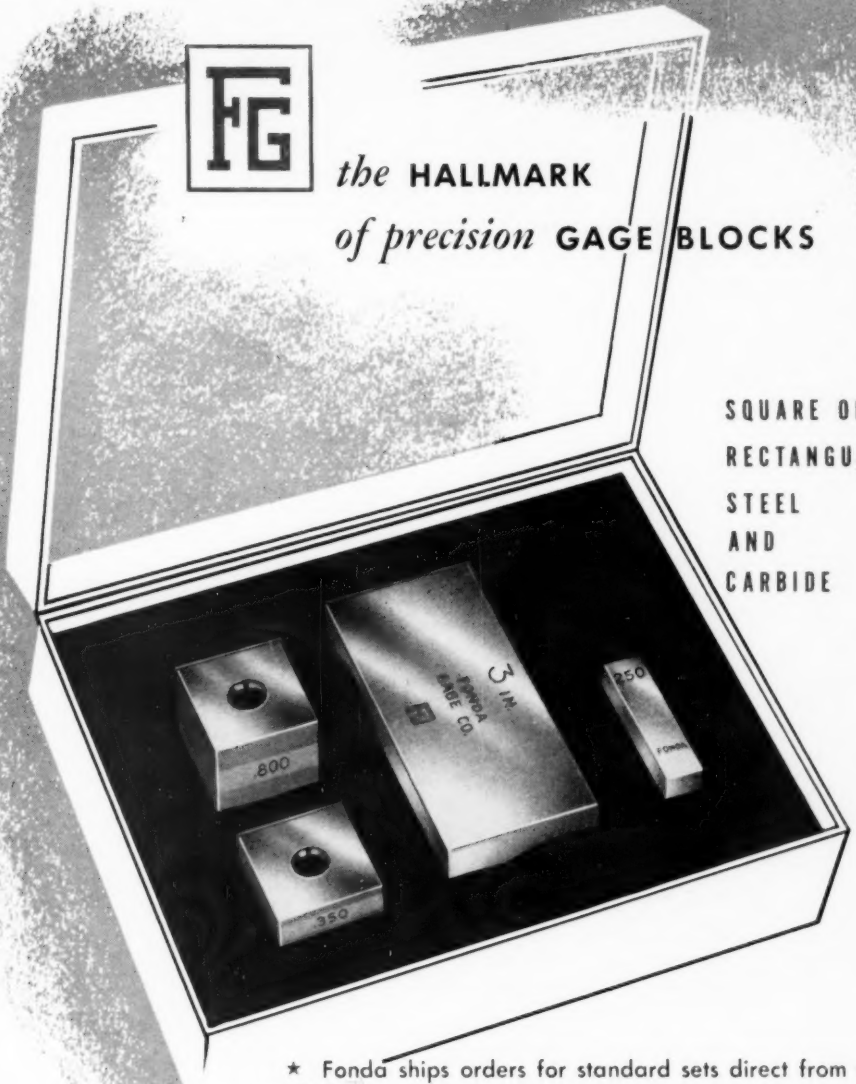

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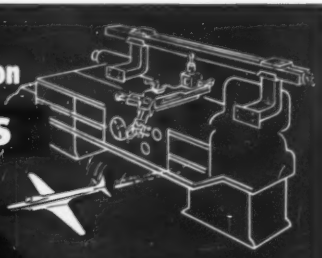

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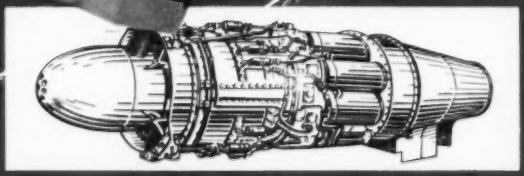

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Latest Developments . . . . Carbide Machining of Heat and Corrosion Resistant Metals

By **Fred W. Lucht**
Engineer-Carbide Design & Application, Carboloy Dept., General Electric Co., Detroit, Mich.

● IN THE APPLICATION of carbides to the machining of heat and corrosion resistant materials, more commonly known as stainless steels, jet engine materials and alloy cast irons, certain definite outstanding trends are always apparent. These trends seem to persist in varying degrees even if these materials belong to the so-called free machining stainless steel classification or to the more difficult to machine high temperature jet engine materials. One supplier of these materials has nicely summarized these trends by the use of the phrase "machining stainless steels is different—not difficult."

The easiest way to recognize this difference is to compare what happens when machining these materials to the machining of ordinary steel which is being handled every day on a routine basis.

When machining ordinary steel with carbide tools most of the heat which is generated while cutting is conducted away from the cut in the chips without experiencing any particular difficulty because only a relatively small percentage of the heat has a chance to flow into the work piece, and into the cutting tool—primarily because a carbide tool retards heat flow better than the high speed steel tools which have

been used in the past. When machining the heat and corrosion resistant materials, which have a higher resistance to cutting resulting in work hardening and also a lower heat conductivity than ordinary steels, less heat flows into the workpiece with a slight increase in heat flow into the cutting tool. This means that a hotter chip is obtained with a varying increase in the tendency for chips to adhere to the cutting edge (build-up edge) based on the type of heat and corrosion resistant material in the workpiece.

The best way to reduce the varying tendency of leaving work-hardened machined surfaces and to minimize the formation of a "build-up" on the tool face adjacent to the cutting edge is to plan the cuts to a greater degree than when machining ordinary steels. This planning should start with the selection of the work material and should follow through step by step to the finished part.

The machinability of the heat and corrosion resistant material being selected for a given work part should be considered as carefully as its chemical and physical properties. This material should wherever possible be put into the best possible machinable state but still meet the conditions of the application in question. The indications are that some of these materials machine much better in the normalized or in a heat treated range (200-250 Brinell hardness) with cemented carbides than in the fully annealed condition. The chip is less troublesome.

The work part should be designed to reduce the number of machining operations to a minimum and each type of operation should be the simplest type

The Boeing B-47E Stratojet, world's fastest operational bomber, is now in production by Boeing Airplane Company's Wichita Division for the USAF Strategic Air Command. The 185,000-pound bomber is powered by six General Electric J-47 jet engines. It carries a three-man crew, is in the "600 miles per hour class," and has a normal bomb load of more than 20,000 pounds. Earlier models of the Stratojet hold records for first jet flight over the North Pole, longest non-stop jet flight (12,000 miles in 24 hours, with aerial refueling), fastest U. S. transcontinental flight (three hours, 46 minutes), fastest U. S.—England flight (four hours, 45 minutes).

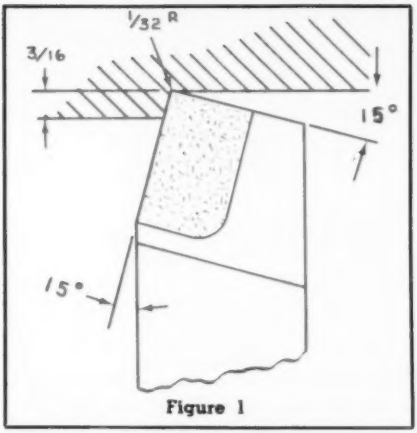


Figure 1

of operation which might involve, for example, the use of single point tools for turning, facing and boring cuts, and face milling cutters for milling. Sufficient stock should be left on the castings to permit the nose of the tool to always work underneath all the hard surface particles.

It is always advisable to know the exact composition of the material being machined and its condition because such information can quickly become an indicator for machining other materials quite similar in analysis and physical characteristics.

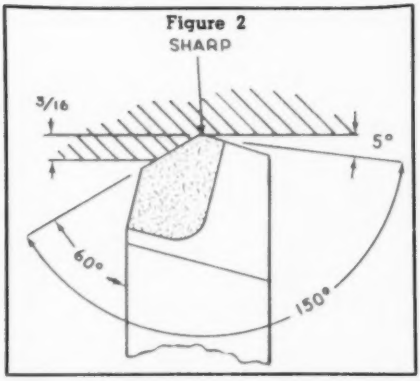


Figure 2

The actual machining routine is a case of conforming quite closely to what is always considered good practice and involves some attention to the following:

1. The tool design
2. The machine tool
3. The setup
4. The operating conditions.

To get the most out of any job, the fundamental thought of rigidity must be kept in mind at all times. This applies to the machine, method of holding the work, method of clamping the tool and the tool itself. A weakness in any one of these items may result in a premature tool failure at the cutting edge. This cannot be overstressed because it is of even greater importance with the heat and corrosion resistant materials than with the ordinary steels.

Tool Design

The tool design was listed as a first because it is advisable wherever possible to select a design of cutting tool which is best adapted to each particular operation or sequence of operations and then select the appropriate machine tool for those operations.

It would be considered advisable to start a new job with a standard type of single point tool with a 15° side cutting edge angle as shown in figure 1 with 6° side rake angle and 0° back rake angle, for a turning cut—if the machinability of the material in the workpiece is questionable. If this tool should fail to stand up sufficiently long, to leave a rough finish on the work, and creates a decided burr where the tool leaves the edge of an interrupted cut, experience has indicated that it would be advisable to increase the 15° side cutting edge angle to 45°, 60° or even 75° with a 7° side cutting edge relief angle as shown in figure 2. The 75° angle operates best for those materials which are most difficult to machine or

if the cuts are of a severe interrupted nature with a scaly surface. The increased angles reduce the cutting pressure per unit length of the cutting edge and give a longer tool life. A certain amount of caution should be used when applying tools with increased side cutting edge angles to a given job because if the part is not sufficiently rigid and the depth of cut is too great, chatter may occur.

It may be advisable to regrind the end cutting edge angle to 3 to 5 degrees at a 7° relief angle leaving the nose of the tool sharp. This gives, for example, a strong 145° included angle at the nose of the tool for a 60° side cutting edge angle and an 5° end cutting edge angle. The sharp corner on the nose of the tool may be "dubbed" very lightly with a 320 grit silicon carbide stone to remove the "dead sharpness" or the grinding burr.

A 2 to 3 degree negative back rake helps strengthen the nose of the tool and tends to neutralize the tendency for the tool to dig into the work. Figure 3 shows this tool with the negative back rake added and also a 6° positive side rake which contributes to a freer cutting action with a minimum tendency for a breakdown of the cutting edge. The indications are that the use of double negative rake angles or increased negative back rake angles without sufficient increased positive side rake angles should be discouraged because they generate an excessive amount of heat which reduces tool life. The back rake and the side rake may be changed somewhat to suit specific applications, but the general trend is invariably in the direction of a slight negative back rake and positive side rake.

Figure 4 shows a well proportioned tool which is better adapted to this type of operation than the tool previously referred to, and can be made by modifying the grind on the simple industry

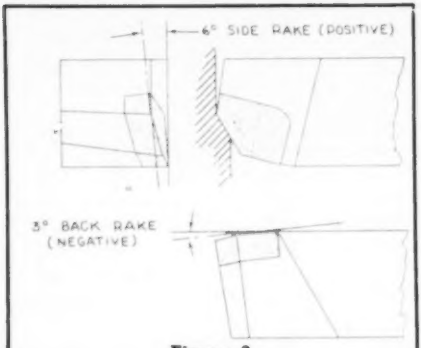


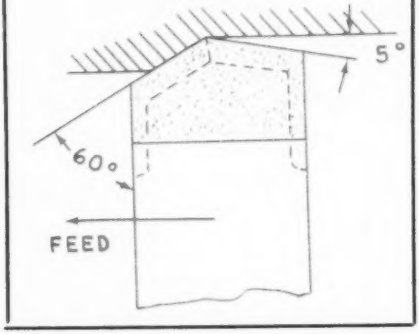
Figure 3

wide standard style C carbide tool.

This particular design of tool with increased side cutting edge angle and a sharp nose produces a chip which has a uniform thickness for its entire width as shown in the enlarged drawing in figure 5. The direction of chip flow is always approximately normal to the side cutting edge angle as indicated by the arrows with a slight tendency for the chips to widen as they leave the cut. The chips also have a natural tendency to curl upward against the unmachined work surface. This chip flow begins to develop a slight crater on the tool face within the confines of the chip path width in the normal manner.

For clarity this is shown again in

Figure 4



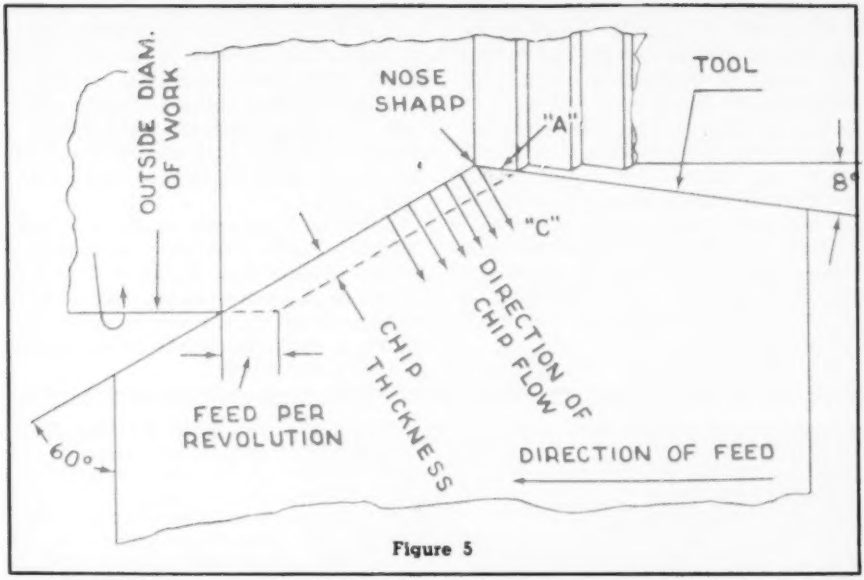
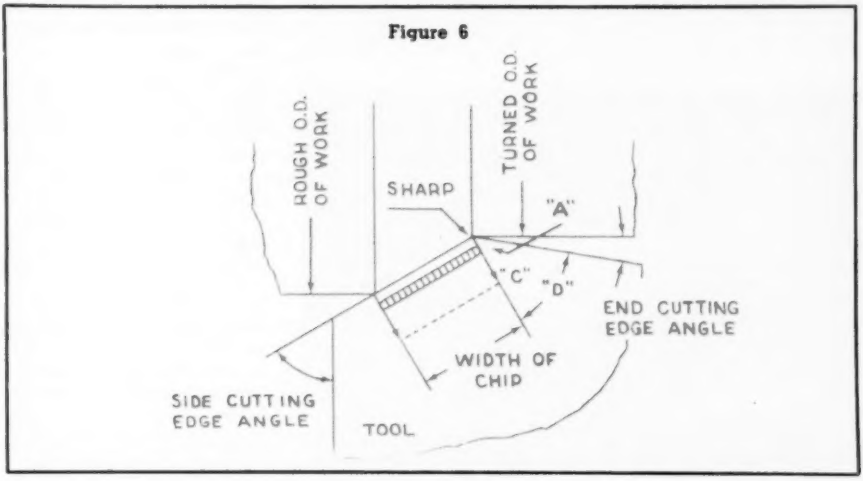


Figure 5

figure 6. This chip flow never touches a portion of the tool face **"A"** located within the angle **"D"** between the arrow **"C"** at one side of the chip flow and the end cutting edge angle at the other side. This particular portion of the tool has a maximum backing behind the sharp nose of the tool in the direction of feed. An analysis of this condition immediately indicates that as the side cut-

Figure 6



ting edge angle is increased from 15° to 45° to 60° or even 75° based on the operation conditions and the end cutting edge angle is reduced to about a 3° minimum, the sharp nose will have its maximum support. As a rule, when this type of tool becomes dull it will still cut to size because the initial breakdown usually occurs along the side cutting edge after the crater has worn sufficiently wide until it reaches the side cutting edge. This offers an advantage because it becomes easier to pick up a cut with a new tool after the tool in use has become dull.

This particular design of tool is extremely free cutting, but still rugged, and produces the coolest possible type of chip. This is why it reduces the troublesome work hardening condition so common when using tools with nose radii to machine heat and corrosion resistant materials. This design of tool is also easier to sharpen than tools with nose radii.

It will be interesting to go back and analyze why the standard type of single point tool as shown in figure 1 is inclined to fail sooner than after it has been modified to the grinds shown in figures 2 and 3. There are several definite reasons for this.

The USAF B-57 Night Intruder, developed by the USAF and The Glenn L. Martin Company from the basic design of the RAF Canberra bomber. It is powered with a pair of Wright Sapphire jet engines produced by the Buick Div. of the General Motors Company. The B-57 is the first night intruder bomber purchased by the USAF.

The F-80 Shooting Star, first mass-produced jet aircraft developed and built by Lockheed Aircraft Corp. This veteran fighter, first American jet plane to enter combat at the outbreak of war in Korea, won history's first jet air battle by shooting down the first Russian MIG-15 jet fighter. The F-80 was the first U. S. jet fighter to be assigned overseas; first American jet fighter to fly the Atlantic and prove practicality of long over-water flights; and the first jet plane to become standard for U. S. Air Force.

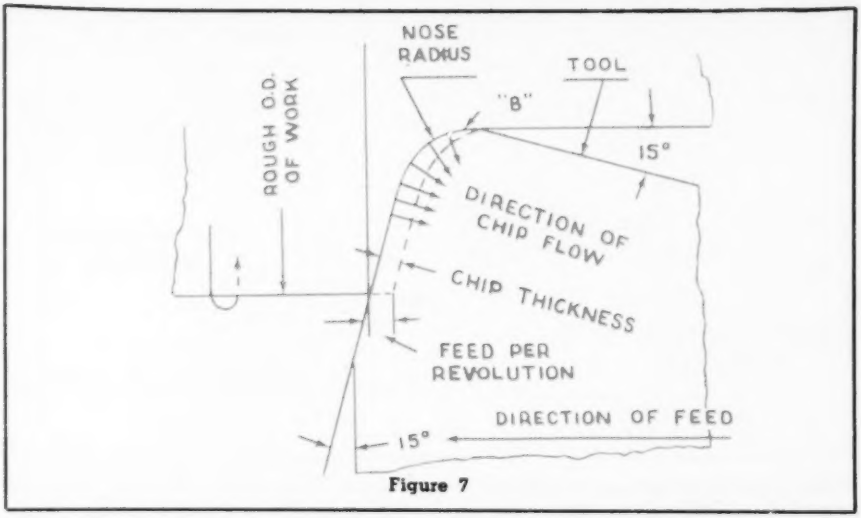


Figure 7

When a tool with a nose radius is fed in the direction shown in figure 7 the chips usually tend to flow normal to the cutting edge about as indicated by the arrows. This means that all the chips produced by the radius portion at the nose of the tool tend to flow toward the center of the nose radius. This creates a chip cross flow action or chip interference which puts added work into the chip and generates excessive heat. The nose radius also develops the thinnest portion of the chip next to the machined surface which is indicated at **"B"** in figure 7. When the increased amount of heat generated from the use of the nose radius is concentrated into the thinner portion of the chip where the chip thickness is vanishing into a zero thickness, the chip becomes exceptionally hot and sticky. This merely aggravates the varying tendency for all the materials in the heat and corrosion resistant classification to stick or weld to the tool face next to the cutting edge and frequently carry a portion of the cutting edge along with it. The thinning chip at **"B"** also develops a highly abrasive type of cutting action which results in a premature dulling of the tool. The general indications are whenever a nose radius is used the abrasive cutting action from the chip thinning effect combined with the excessive heating and cooling of the chip tends to increase the work hardening tendency and shortens the life of the tools used for machining these materials. The resulting work hardened machined surface is also detrimental to good machining practice and shortens the life of the tools used for subsequent operations. The first sign of breakdown of the cutting edge from machining a part with a work hardened surface on it appears as a notch worn in the side cutting edge of the tool where the work hardened surface contacts it as shown in figure 8. This is known as "notching." The best way to eliminate this condition is to go back to the source of the trouble and plan on using a properly designed free cutting tool similar to or like the tool shown in figure 4.

It has been found when machining heat and corrosion resistant materials,

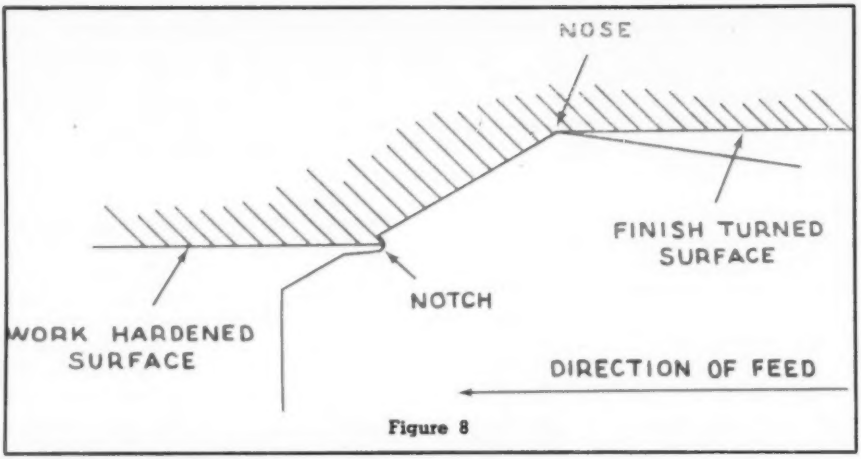


Figure 8

which belong to the most difficult to machine classification, that the increased resistance to cutting generates so much heat that the chip obtained from a tool as shown in figure 4 may still be inclined to stick to the tool face when interrupted cuts are taken.

This difficulty can be reduced by modifying the grind on the tool face still more to that shown in figure 9.

This increases the normal side rake angle, which is measured perpendicular to the side cutting edge, to 12° - 15° (positive). This is also the approximate direction of chip flow. Then grind a land having a width equal to 1 to 1½ times the feed per revolution at a 0° - 3° effective negative normal side rake angle and parallel to the side cutting edge angle. This type of grind reduces the area of chip contact with the tool face to a minimum and it remains at a minimum throughout the life of the tool. When the tool is dull the chip may have scooped out a crater as shown by the shaded portion in the enlarged view in figure 10. Contrast the reduced size of this crater cross section with that obtained when a tool with the entire face is ground at a 3° negative angle behind the cutting edge as shown in figure 11. The reduced length of the crater contour and the depth of the crater shown in figure 10 quickly indicate why a cooler chip with a minimum tendency for it to stick to the cutting is obtained from this freer cutting type of tool. A keen cutting edge without any blemishes in it will also reduce the tendency for chips to stick to the cutting edge and give the longest tool life. To obtain such a cutting edge when sharpening single point turning tools, it is advisable to use particular care in grinding both the tool face and the relief angle behind the side cutting edge. Surprisingly good tool life has been obtained from tools sharpened to a 2-3 micro-inch finish on these two surfaces with a resinoid bond diamond cup wheel well flooded with a coolant removing about .0002 of carbide only per pass at 6 inches per minute feed rate for the final pass. It is well to re-emphasize the fact that the longest tool life is always obtained if a silicon carbide (not a resinoid bond diamond) cup wheel is used for removing both steel and carbide and the resinoid bond diamond cup wheel is never used for grinding anything but

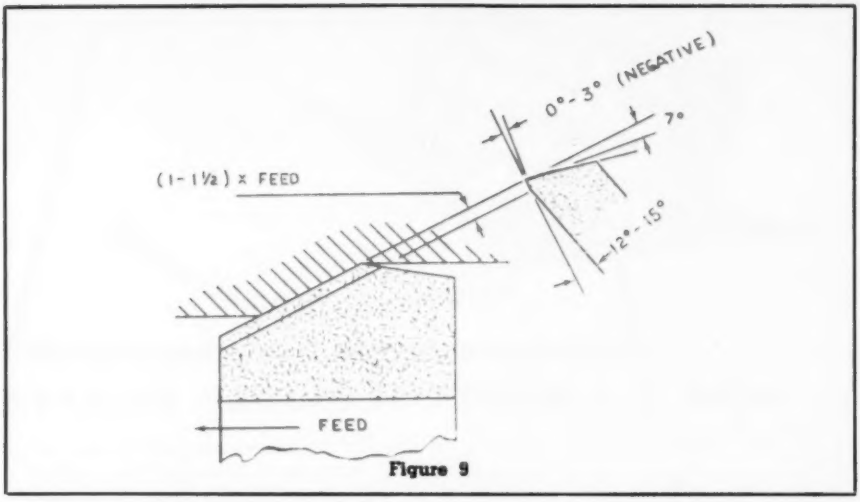


Figure 9

carbide. It is advisable that the cutting edge left by the final pass across the diamond wheel is brushed lightly by a 320 grit silicon carbide stone to remove the grinding burr but not stoned (dubbed) at a 45° angle as is customarily recommended for steel turning tools.

The Machine Tool

The machine tool should not only be simple in design but also rugged in construction. Ample power should be available at all times. It is advisable to never operate the machine too close to the

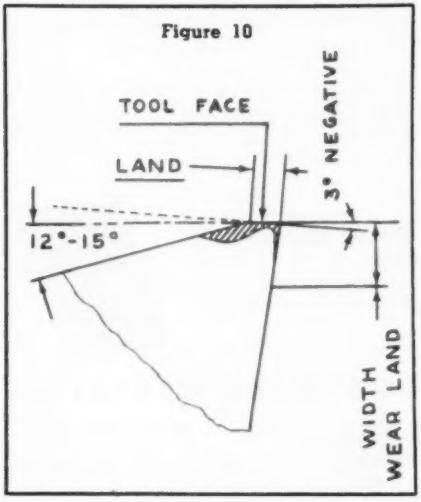


Figure 10

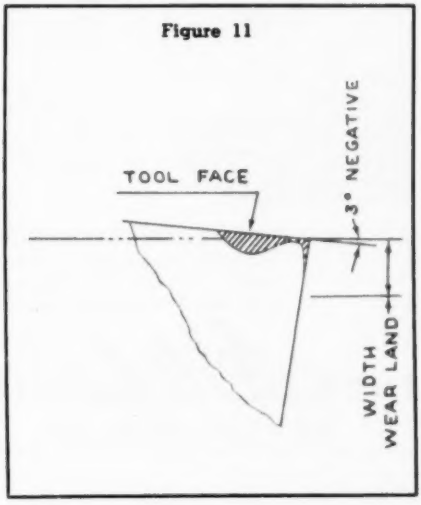
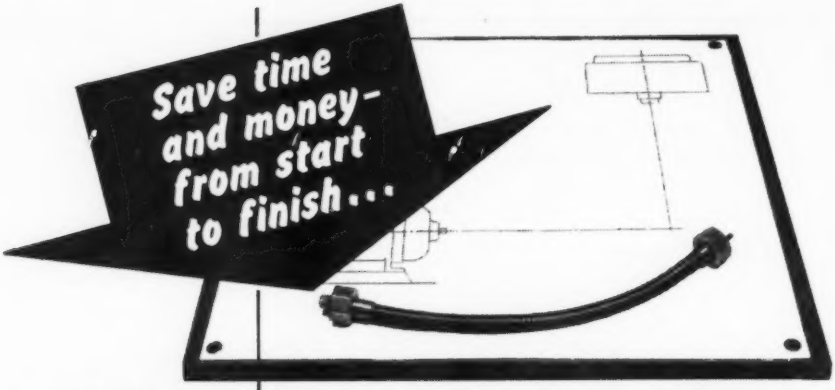


Figure 11



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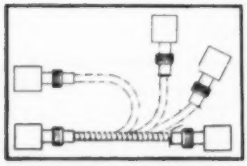

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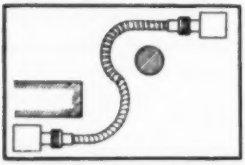

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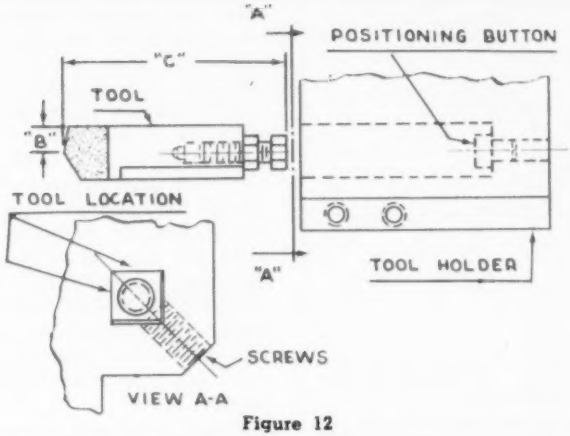


Figure 12

overload power range because the resultant variations in the over-all performance may not only retard the cutting speed but may also even stop the machine when a tool becomes exceptionally dull or the cut should become deeper than normal.

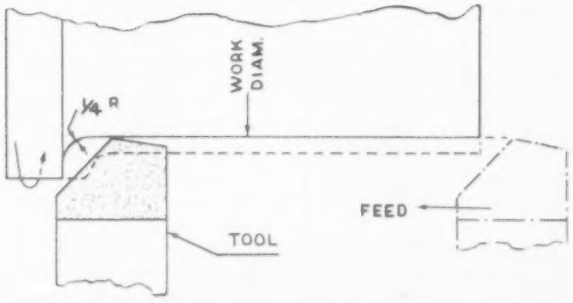
All spindle end-play, looseness of gibs in slides, the improper doweling of one machine member to another, insufficiently long slides, excessive tool post overhang, the setting up of unbalanced forces in the machine or in fact any condition which might encourage vibration or chatter should be kept at a minimum.

The Setup

It is a known fact that the machining of parts made from heat and corrosion resistant materials is never as economical as the machining of like parts made from ordinary steel. The main reasons for this are:

1. The tools dull faster.
2. The tools have to be changed oftener.
3. The more frequent tool change will

Figure 13



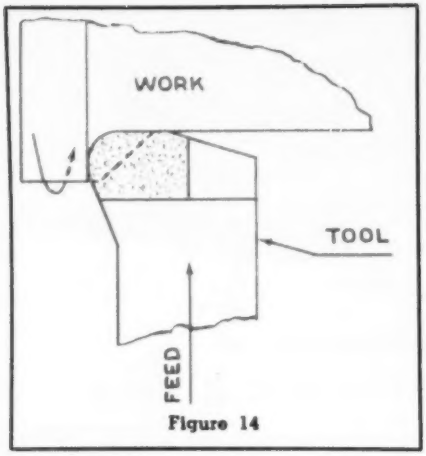


Figure 14

increase the machine down time.

4. The tools have to be sharpened oftener.

This is an immediate indication that some definite planning is in order to make the machining of these materials relatively economical.

The tool shape should be simple in outline to make the tool relatively easy to sharpen. It is advisable that such a tool is incorporated into a quick change tool holder idea as shown in figure 12. A simple L-shaped grinding gage should be used to aid in maintaining a constant dimension "B" from the locating side of each tool shank to its nose while sharpening. After each tool has been sharpened the over-all tool length should be adjusted and set to a common gage length "C". This means that after a dull tool has been removed from the tool holder a resharpened tool can be inserted in its place into the tool holder slot, moved endwise until it contacts the hardened positioning button and then quickly clamped in place. Two screws are shown for simplicity to not only force but also clamp each tool against the two tool location surfaces in the tool slot. The use of either cams or hydraulic clamping or pneumatic clamping will reduce the time for this clamping operation to practically an absolute minimum.

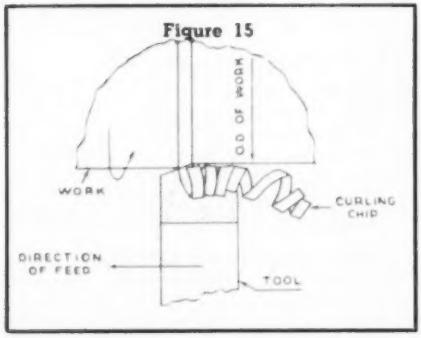


Figure 15

Many parts which are subjected to severe stresses at elevated temperatures require the use of generous fillets to provide the necessary strength in corners. Such a part is shown in figure 13 and the first thought would be to use one tool with a ¼" nose radius to take both the turning and the final facing cut up to the 90° shoulder in one operation. Such a tool would be inclined to break down rapidly if it took the complete turning cut.

It would be advisable to use the more efficient type of tool as also shown in figure 13 which has an increased side cutting edge angle and a sharp nose to remove all the rough stock and scale not only from the outside diameter but also from next to the shoulder. With this setup the less efficient ¼" radius tool would only have to take a short facing cut at the shoulder in clean metal and would give a relatively long tool life. The radius tool is shown taking a facing cut in figure 14 which also aids in maintaining the shoulder location.

To machine heat and corrosion resistant materials it is advisable to always use tools with shank cross sections sufficiently large for the job in question. Proper allowance should be made for

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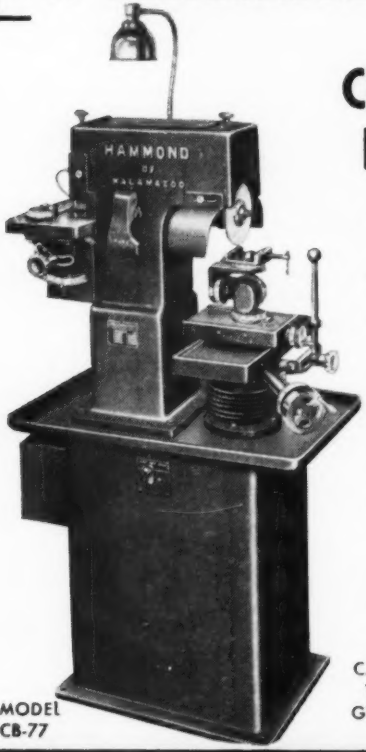

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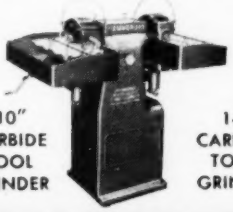

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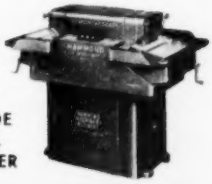

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Table I. Machinability Rating Heat and Corrosion Resistant Materials

Heat and Corrosion Resistant Classification		Machinability Rating Percent	SAE and AISI Classification	
Material	Hardness Brinell		Hardness Brinell	Material
				SAE 1112-CD .10 carbon, .18 sulphur
		—100—	200	
		— 95—		
Type 303-Cold Finish	159			
Type 416-HR-Ann. C.D.	174	— 90—		
Type 416-C.D.	226			
Type 416-HR-HT-C.D.	217			
Type 416-HR-Ann.	229	— 85—	126	SAE 1010-HR
Type 303-Ann.-C.D.	288	— 80—		
Type 303-HR-Pickled	167	— 75—		
Type 410-HT	293	— 70—		
		— 65—	160	SAE 1045-HR
		— 60—	170	AISI 4142-HR-Ann.
Type 405-HR	170			
Type 310-HR	187	— 55—	137	SAE 1010 C.D.
Type 410-HR-Ann.-Pickled	293			
Type 405-HR	229	— 50—	179-235	SAE 6145-Ann.
			187-214	SAE 4340-Ann.
Type 403-HT	220	— 45—	225	SAE 1095-C.D.
			187-214	SAE 2340-Ann.
Timken Alloy (16-25-6) HR	225	— 40—		
		— 35—		
Type 347-HR	157			
Type 302-CD	179	— 30—		High Speed Steel (Spherodized Anneal)
Type 410-HR	217			
S-816 HT + one hour age	250			
				High Carbon—High Chrome Tool Steel—Spherodized Anneal
S-816 HT + six hour age	257	— 25—		
Timken Alloy (16-25-6) HR	277			
Type 347-Ann.-C.D.	182	— 20—		
Inconel X	302	— 15—		
S-816, HT-16 hour age	288			
Vitallium		— 10—		
		— 5—		
		— 0—		

Ann.—Annealed C.D.—Cold drawn HR—Hot rolled HT—Heat treated

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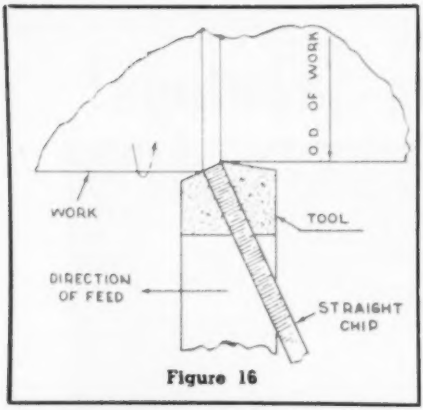

Figure 16

the impact from cuts of an interrupted nature. If the shank size is questionable it is advisable to use the next larger standard shank cross section and to hold the shank overhang at a minimum to eliminate all possible chance of vibration from the heavy loading of the tool shank.

If a tool is permitted to dwell in the cut or at the end of a cut a work hardened surface will develop from it which will make it difficult to machine this surface in a subsequent operation. This will not only cause the nose of the tool which is doing the machining to wear rapidly but will also develop notching in the cutting edge of the tool used for the following operations. If the tool movements are controlled by cam action, the cam profile should be modified to keep the tool in a continued forward motion as much as possible even when dwell points are reached and then quickly retracted away from the cut. In other words, it is always advisable to maintain a chip of some definite thickness.

There should always be a continuity to the cutting action when machining these materials or in other words a uniform feed per revolution will always give the longest tool life. Any feed mechanism on a machine tool which is inclined to slow up and then given a sudden surge ahead will not only result in an erratic tool life but will also give a bad finish on the machined work surface.

The cutting edges on the tools used to machine these materials should always be kept reasonably sharp. To accomplish this it is advisable to determine as a result of several runs on a production type of job at what number of workpieces a tool breakdown will occur and then always remove the tools at some definite lesser number of pieces for sharpening. This will minimize the danger of producing work hardened surfaces on the part being machined. When a tool has reached that certain

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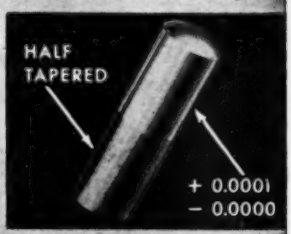

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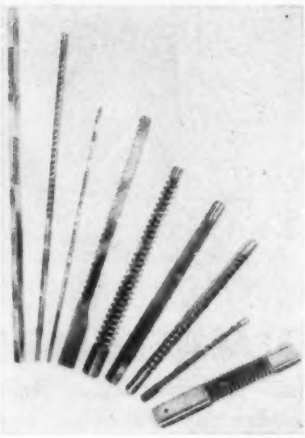

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degree of dullness where it might fail while machining the next part there is no advantage in starting to machine that part because it might result in a damaged tool as well as a ruined workpiece. This in turn will place an added burden on the tool grinding department.

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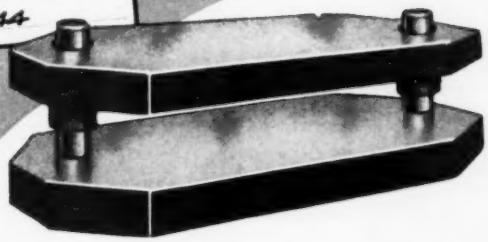

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ure 15 the chip will short off in a direction roughly perpendicular to the side cutting edge angle as shown in figure 16. This straight chip which is obtained when vibration occurs also closely follows the tool face, generates much heat and quickly adheres to the tool face next to the cutting edge. The tool failure will be premature and will appear as chip-outs along the cutting edge.

Operating Conditions

One of the first items to be considered after placing a carbide tipped single point tool in the tool post of a rugged lathe with ample power available is the selection of a suitable cutting speed for the workpiece material being machined. The cutting speed used for most of the heat and corrosion resistant

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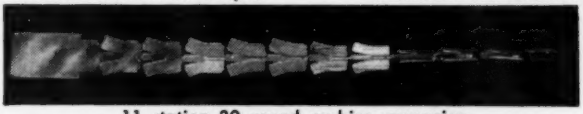

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materials is quite critical and is usually confined to a limited range based on the machinability of the material in question. As a general rule, the lower the machinability rating, the more critical the use of the proper cutting speed, the proper rake angles, the correct cutting angles and relief angles on the single point tool becomes.

In the past, there have been frequent sad experiences in many shops when they start to machine their first part, made from a material in the heat and corrosion resistant classification. This has been very pronounced when applying cutting speeds such as used for ordinary steel.

This prompted the running of a series of machinability tests to determine how several types of stainless steels in different conditions such as heat treated, hot rolled, cold drawn, etc., rated with, for example, SAE 1112, SAE 1045, etc., steel.

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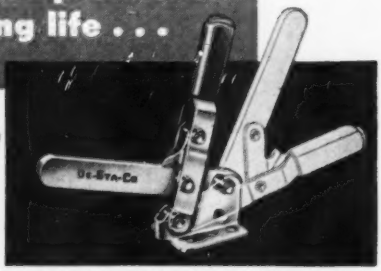

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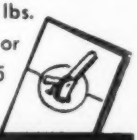

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Table I shows some of the compiled results on the basis that cold drawn SAE 1112 steel with a 200 Brinell hardness has a 100% rating. The machinability rating in percent is given in the center vertical column with the heat and corrosion resistant material at the left hand side and the more ordinary steels at the right hand side of the table.

No specific cutting speeds will be given for use with these materials at this time since this data only indicates that every type of stainless steel should, for example, have some appropriate cutting speed and that speed is usually lower than that ordinarly used for machining steel.

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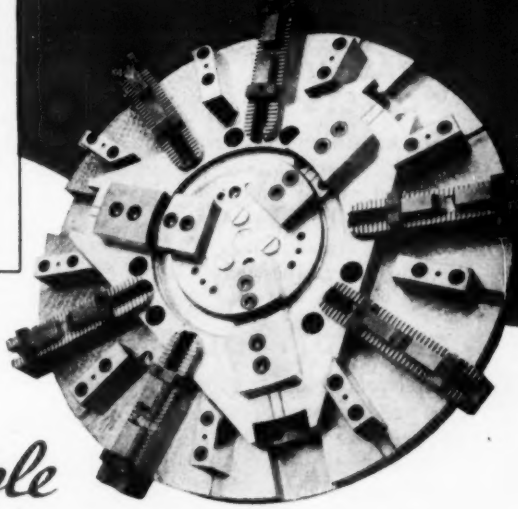

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gives fine performance but if cuts are of a rougher nature, Grade 44A, a stronger grade of carbide, will better resist any tendency of breakdown of the cutting edges. On some jobs if there is any tendency to a heavy crater action at the tool face, a steel cutting grade of carbide like Grade 78 has given longer tool life.

REFERENCES

1. Titanium: Report on General Machinability, MACHINE and TOOL BLUE BOOK, July 1952, J. Joseph.
2. Experience In Machining Titanium Alloys, STEEL, October 1, 1951, J. McElgin.

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Machining the Aviation Gas Turbine High Temperature Alloys

By **D. C. Goldberg**
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Metallurgical Eng. Sect'n.
Aviation Gas Turbine Div.
Westinghouse Elec. Corp.
So. Philadelphia, Penna.

and

H. O. J. Hanzlick
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● THE USE of gas turbines to propel modern aircraft is constantly increasing. The materials utilized in the construction of these engines vary from magnesium and aluminum in the compressor to Stellite 31 and Discaloy in the turbine. The wide variation in machining characteristics of the various metals introduces many problems.

To permit analysis of the metallurgical requirements for the different components of aviation gas turbines as well as the tooling required to fabricate the parts, the engine has been divided into four main components.

1. Compressor—discs, blades, housing, diaphragms, shaft
2. Combustion Chamber—flanges, bosses
3. Turbine—housing, liners, nozzle vane and shroud, blades, discs, shaft
4. Afterburner—flanges, bolts, miscellaneous hardware

Figures 1 to 5 show the materials that are used in the engine parts as well as their nominal chemical analysis. Although a wide variety of materials can be used, their design properties metallurgically are similar (on a weight/strength basis). Needless to say, each material presents different machining problems—feeds, speeds, tooling, and coolants.

Compressor

As shown in figure 1, the compressor utilizes a variety of light alloys—aluminum, magnesium, and titanium—as well as such materials as 12 percent Cr-Fe and SAE 4130.

Aluminum and magnesium normally offer no machining problem to the average shop. For these materials the maximum speeds of machine tools usually can be used with heavy cuts and high feed rates. Also, the power requirements for magnesium and aluminum alloys are only 20 to 25 percent those for the mild low alloy steels.

In the manufacture of aviation gas turbine components, where thin sections, close tolerances and high thermal expansion rates are the rule, special tooling is desirable and can be justified.

In lathe and boring mill operations, special precautions must be taken in setting up a job to avoid improper fixtures and high clamping pressures. During the machining of light sections of aluminum and magnesium alloys, distortion can also result from overheating caused by dull tools, improper tool design, light cuts, dry cutting, and heavy cutting on thin sections.

The tool material can be carbon steel, high speed steel, cast alloys, or carbide. Back- and side-rake angles, which may vary considerably, are usually zero to 15 degrees with high-speed tools and zero to eight degrees with carbide. Relief angles should be generous: 8 to 12 degrees. Side and end cutting-edge angles vary with the job but the former should not be more than 30 degrees to avoid chatter. Also, back rakes of more than eight degrees will cause chatter. Finishing tools should have small radii to avoid rubbing.

To avoid distortion and dishing (resulting from internal stresses) in aluminum compressor discs, it is good practice to take alternate cuts on each side of the disc, each cut with a progressively smaller depth of cut; this is, 0.060 in., 0.030 in., 0.010 in. Heavier feeds and depth of cuts results in poor finish. Surface speeds ranging from 150 to 800 sfpm on aluminum discs are used, while in the machining of housings 2000 sfpm is not unusual.

The machinability of magnesium is illustrated by the speeds used in milling this material (1000 to 3500 sfpm), usuually the machine tool's maximum.

1. Compressor Materials for Jet Engine

Compressor Parts	Alternate Materials
Discs	Aluminum—14 ST and AMS-4135 12% Cr-Fe—AMS-5613, and AMS-5615 Titanium—Cr-Fe alloy and Al-Mn alloy SAE 4130 (AMS-6350)
Blades	Aluminum—F18ST 12%Cr-Fe—Special AISI 403 analysis Titanium—Commercially pure and Al-Mn alloy
Housings	Magnesium
Diaphragm	12% Cr-Fe
Shaft	12% Cr-Fe Low alloy steel

(Aluminum can be milled at rates approaching these figures.) Depth of cut is determined by the job, while feeds (ranging from 0.004 to 0.025 inch per tooth) vary with speed and depth of cut. At high speeds, the table will travel 10 to 30 inches per minute.

In the design of cutters, it is imperative to either allow a maximum chip clearance or reduce the number of teeth. Cutter design calls for rake angles from 5 to 20 degrees, and relief angles of 7 to 10 degrees (backed off 20 degrees).

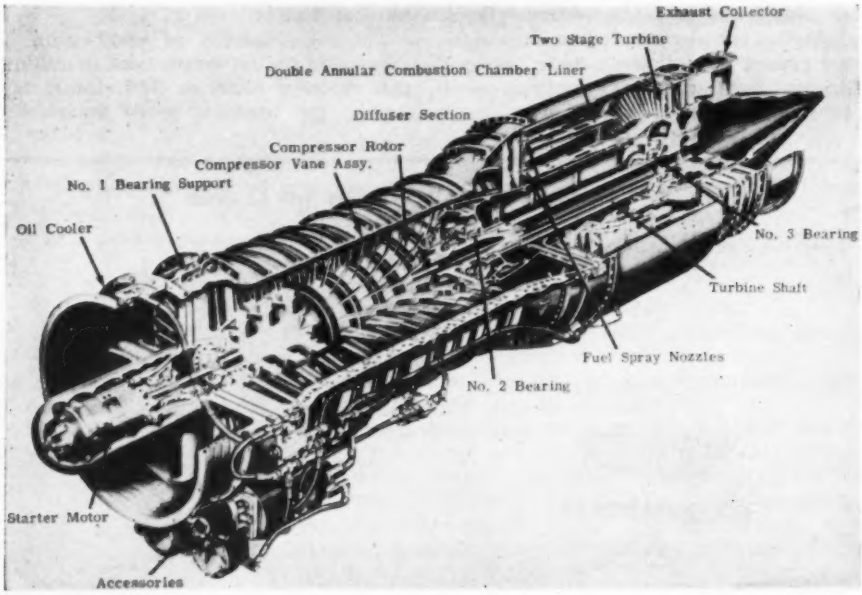
Broaches for dove-tail roots in aluminum compressor discs utilize standard T-1 (18-4-1) steel with rake angles of 10 to 15 degrees and a relief of one to three degrees. Large chip spaces and good grade of cutting oil should be provided. Chip loads of 0.005 inch to 0.004 inch per tooth are used in roughing, with the finishers loaded 0.002 inch per tooth.

Drilling, reaming, and tapping operations for aluminum and magnesium alloys are similar except the magnesium permits faster metal removal.

Drilling shallow-holes as deep as five times hole diameter can be accomplished readily. The point angle may vary from 70 degrees to the standard 118 degrees with chisel-edge angles 120 to 135 degrees. Lip relief should be about 12 degrees. A standard helix of 25 degrees can be used, or the helix can vary from 10 to 30 degrees. Drill speeds from 150 to 400 sfpm are in general used in the shops, while the feed can range from 0.015 to 0.040 ipm for a ½ in. diameter hole.

In reaming operations on ½ in. diameter holes in aluminum and magnesium, four-fluted straight reamers are recommended. The reamer design most generally used has a five to eight de-

Cutaway view of J34 turbo-jet engine.



2. Combustor Materials For Jet Engine

Combustion Chamber Parts	Alternate Materials
Flanges	Half-hard 18/8 stainless steel AISI 310 (AMS-5521) Low alloy steel 18/8 Ti, stabilized (AMS-5645)
Bosses	AISI 310 (AMS-5521) 18/8 Ti, stabilized (AMS-5645)

grees rake, four to seven degrees relief, 15 to 20 degrees clearance with a metal removal of 0.030 inch on the diameter. For the close tapping requirements in magnesium housings and aluminum discs, special high-speed steel taps are required with wide straight flutes (three from ¼ to ¾ inch), rake angle of 10 to 25 degrees, with a heel rake of three to five degrees. Tapping speeds from 75 to 200 sfpm with a good cutting fluid and the above tap design produces consistently good results.

Although titanium and titanium alloys are coming into greater use, full production application has not yet been seen. Methods of machining this material have been described fully in many articles (Ref. 1, 2).

The material for which titanium is most generally substituted is the 12 percent Cr-Fe alloy. This 12 percent

3. Turbine Materials For Jet Engine

Turbine Parts	Alternate Materials
Housing	AISI 310 (AMS-5521), cast or forged
Liners	AISI 310 (AMS-5521) Low alloy steel Titanium—Al-Mn alloy
Nozzle Vanes	Refractaloy 80 Hastelloy C
Shrouds	AISI 310 (AMS-5521)
Blades	Stellite 31 (AMS-5382) Wrought Ni-base alloys
Discs	Discaloy (AMS-5733) 12% Cr-Fe alloy, modified Titanium
Shaft	Discaloy

Cr-Fe alloy has almost universal use for such gas turbine applications as compressor vanes, blades, discs and diaphragms. It is used in either the rolled, forged, or cast condition at a BHN range of 180 to 250. The material at this hardness level is characterized by a tough, non-abrasive, stringy chip. It is not considered work-hardenable but it does tend to "tear-out."

Machining operations performed on compressor components made from 12 percent Cr-Fe alloy include turning, broaching, milling, drilling, reaming, and tapping. Use of carbide tools results in longer tool life and better surface finish.

The hardness level at which the 12 percent Cr-Fe alloy is machined is produced by air quenching the parts from 1750 degrees F followed by a temper at 1200 degrees F. The resultant microstructure is suitable for most machining operations. When better surface finishes are desired, they are achieved by varying the heat treatment to produce a higher hardness level. It is not unusual today for an engine designer to satisfy the shop by permitting use of the higher BHN in order to obtain better finish, and also obtain a lighter part by utilizing the higher strength of the heat-treated part.

The machining of compressor discs from the 12 percent Cr-Fe alloy is straightforward. The main problem is in obtaining good RMS finishes. Rough and finish turning is best carried out with a carbide (C-2) tool using a zero degree back rake, six degrees side rake, zero degree side cutting edge angle, six degrees end cutting edge angle and a radius of 0.040 inch. These figures will vary somewhat depending on the operation. In rough turning, the speeds generally used are 150 to 200 sfpm with a feed of 0.005 to 0.025 ipm and depth of cuts ranging from 0.030 to 0.125 inch. In making finish cuts, speeds of 200 to 400 sfpm are specified with feeds of 0.003 to 0.010 and depth of cuts from 0.003 to 0.030 inch.

Broaching of the dovetail slots is probably the most difficult operation in the manufacture of 12 percent Cr-Fe compressor discs chiefly because of the difficulty in obtaining a good finish. Continued development work on this activity has overcome the problem to a great extent. It has been found that a properly ground broach made from T-2 (18-4-2) steel using a highly-chlorinated wax-type oil produces the longest broach life and best surface finish. The broach speed used is 37 sfpm, while

4. Afterburner Material For Jet Engine

Afterburner Parts	Alternate Materials
Flanges	AISI 310 (AMS-5651) Age-hardened stainless steel (17-7 PH) Discaloy
Bolts	Discaloy (AMS-5733) Refractaloy 26 AISI 310 (AMS-5651)
Hardware	Discaloy AISI 310, Cast and forged Inconel X, W

the broach design calls for a chip load of 0.004 inch per tooth on the roughers and 0.001 inch per tooth on the finishers using a rake of two degrees.

Drilling, reaming, and tapping operations on 12 percent Cr-Fe follow standard practice. Type T-1 or other good quality high-speed steels can be used. Drills using a 140 degree point angle at speeds of 40 to 80 sfpm with a feed of 0.003 to 0.007 ipm give good results. Tapping is performed at 10 to 25 sfpm and reaming at 15 to 40 sfpm with a 0.002-inch tooth load and a depth of cut of 0.060 on the diameter.

In all cases, it is important to use highly-chlorinated wax-base-type cutting oils except in turning, where good use can be made of the water solubles.

Increasing use is being made of low alloy steels for compressor discs as part of critical alloy reduction programs. SAE 4130, 4140, 4340 in the hardness range of 180 to 260 BHN are the alloys most generally specified. This hardness is developed using a quench and temper cycle. This treatment produces a structure which is amenable to most machining operations.

In 1939 the ASME published data on turning low alloy steel. This information still remains the basis for setting of most machine rates and establishing tool designs, figure 6.

In rough turning with depth of cuts from ⅛ to ½ inch and feeds of 0.015 inch using hss tools, 50 to 85 sfpm should be used. For finishing, 50 percent higher speeds can be used with corresponding decreases in feeds and depth of cuts. Use of carbides (C-6 grade) for a similar range of cuts allows the operator to cut at surface speeds three times those quoted above.

When using carbides it is desirable to grind a chip breaker on the tool in order to break up chips. A chip breaker depth of 0.020 inch has proven advantageous. The width will necessarily vary with depth of cut and the feed. For example, a depth of cut of 0.030 inch and a feed of 0.015 ipm calls for a chip breaker 5/64 inch wide, while a depth of cut of 0.500 inch for the same feed requires a 5/32-inch-wide chip breaker.

Broaches used on the low alloy steels are made from a T-1 or T-2 steel operated at 12 to 18 sfpm. A typical broach design for making a dovetail root in a compressor disc requires a ½ inch pitch, ⅛ inch land, 3/16 inch depth, and a ⅛ inch radius. The face angle for this material in the 250 BHN range should be 10 to 15 degrees while the rake angle should be from three degrees to ½ degree.

The tooth load is generally 0.004 inch for roughers and 0.002 inch for finishes. It is highly desirable to make use of a shear angle of 5 to 10 degrees to obtain improved finishes. Chlorinated wax-type oils at a 200 viscosity are used successfully in this operation.

Drilling, tapping, and reaming operations on low alloy steels offer no problem to the production shop. Standard

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5. Composition of Materials for Jet Engines

MATERIAL	Nominal Composition %								
	Cr	Ni	Mo	Ti	Al	Mg	Fe	Co	Other
Aluminum, 14 ST	0.1				Bal	0.5	1		
Magnesium						Bal			3-5% Rare Earths, 0.75% Zr.
Titanium, C.P.				Bal					
Titanium, Mn-Al				Bal	4				4% Mn
Titanium, Fe-Cr	2.3			Bal			1		
SAE-4130	0.95		0.2				Bal		
SAE-4340	0.8	1.8	0.25				Bal		
AISI-410	12						Bal		
AISI-414	12	2					Bal		
AISI-302	18	10					Bal		
AISI-321	18	10		0.5			Bal		
AISI-310	25	20					Bal		
Discaloy 24	13.5	26.2	3.9	1.6	0.1		Bal		
Refractaloy 26	18	37	3	2.8	0.2		18	20	
Refractaloy 80	20	20	10				14	30	
Stellite 31	25	10						55	
Hastelloy C	16	57	17				5		
Inconel X	15	73		2.5	0.7		7		
Inconel W	14	75		2.5	0.6		7		

6. Tool Design Data For Turning Low Alloy Steel (ASME)

Designation	High Speed Steel	Carbide Steel
Side rake	5-15 (10) degrees	0-15 (8) degrees
Back rake	5-10 (8) degrees	0-10 (0) degrees
Side relief	6-10 (8) degrees	4-12 (7) degrees
End relief	6-10 (8) degrees	4-12 (7) degrees
End cutting-edge	6-15 (10) degrees	8-15 (10) degrees
Side cutting-edge	0-30 (15) degrees	0-10 (15) degrees
Nose radius	10% of cut depth	0.030 inches

Figures in ( ) represent average used.

tooling can be used with little trouble at high production rates.

There has been some tendency to use low alloy steels at hardness levels of 350 to 400 BHN. Operations performed on the disc at this hardness level are finish turning, drilling, reaming, and broaching.

To do these operations, modifications of standard practice must be made. For instance in drilling, the point angle should be increased from 118 to 150 degrees, the lip clearance should be reduced from 10 degrees to 5 degrees, and the drill should have a heavier web structure, thinned at the point, and be designed with a slower helix angle. Cobalt high-speed steel drills should be used rather than the standard hss.

Compressor blade roots are either broached or milled. Use of good oils or waxes, plus broach design similar to that described earlier, will result in long tool life and good finishes at speeds of 12 to 24 sfpm. Advantage is taken of the ability to obtain a better finish at a small sacrifice in tool life, by broaching blades at a BHN of 320 to 40. Subsequent heat treating operations bring the blade into its proper metallurgical structure.

Combustion Chamber

Aft of the compressor is the combustion chamber. In Westinghouse jet engines the annular design is used. In this design, a large-diameter sheet-metal housing to which flanges have been seam welded is bolted to the compressor housing and the turbine housing. So far as the detail machine shop is concerned, the chief machining operations here are the rough and finish turning of the flanges and drilling the bolt holes. There are also miscellaneous bosses welded to the housing which have milling, drilling, reaming, and tapping operations performed on them.

The materials specified for the combustion chamber are Types 310, 321, halfhard 18/8, 410, 4110, and NAX steel. Carbide (C-2) tools are generally used in turning the flanges. Because the cross-sections are small and diameters large, considerable attention has to be placed on having the proper tool grind, a sharp cutting edge, and rigid fixtures. If the tool does not take a clean chip, there will be a tendency for the tool to ride on the flange, causing distortion, poor finish, and a work-hardened surface.

Full advantage of the machinability of these materials cannot be taken because of the part design. However, roughing speeds in the order of 90 to 150 sfpm and finishing speeds of 130

7. Machining Data On Discaloy

Turning	Depth	Feed	SFPM
Roughing	¼ inch	.010-.015 inch/rev	100 - 140
Semi-Finish	.050 inch	.008-.012 inch/rev	140 - 230
Finish	.010 inch	.006-.008 inch/rev	90 - 230

Coolant—water-soluble oil
Tool—C-2

Broaching

Speed—15 to 20 sfpm (average)
Tool—T-2; Design of broach varies with the design of root and broach length available. Rigidity of fixtures and sharpness of broach are key factors to obtaining finish and proper size.
Coolant—Chlorinated wax-base oil.

Drilling

Tool—Cobalt H.S.S.
Coolant—Chlorinated wax-base oil
Speed—15 to 30 sfpm
Feed—0.007 to 0.010 ipr (¼ to ½-inch-diameter holes).
Design—135 to 140° Drill point angle
6 to 8° lip relief

Reaming

Tool—Cobalt H.S.S.
Coolant—Chlorinated wax-base oil
Speed—15 to 30 sfpm
Feed—0.001 inch to 0.002 inch per tooth
Depth—0.030 inch on radius.
Design—Straight fluted or right hand spiral

to 180 sfpm are usually specified. Type 310 and 321 flanges, after being rough turned, are given a high temperature stress relief to facilitate the subsequent finish machining operations and to stabilize the parts.

The drilling operations on the flanges and bosses are classified as shallow-hole drilling. The austenitic 25 Cr-20 Ni (AISI 310) and 18/10 Ti (AISI 321) stabilized grades present a problem in drilling due to their work-hardening tendency. The drill should be sharpened with a 135 to 140 degree point angle and with a six to eight degree lip relief. It is necessary also to thin the drill web at the point to prevent rubbing action of the chisel edge on the material.

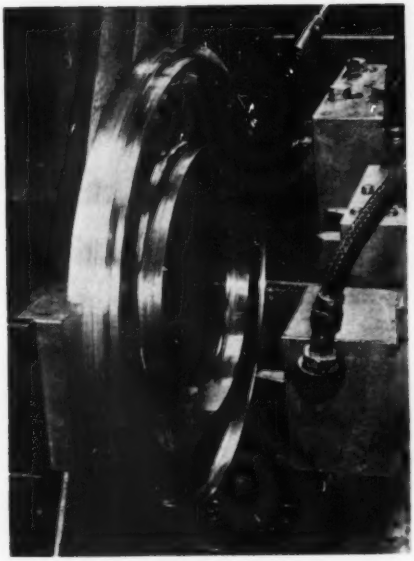
The drill speed can vary between 20 to 50 sfpm depending on the hole size with a corresponding drill feed of 0.002 to 0.005 ipm. Use of slow speeds, high feeds, sharp edges, and short drills minimize the problems.

Other operations performed on these alloys present no specific problem. Reference should be made to publications of the Metal Cutting Institute for specific tool design practice for milling cutters, taps, and reamers.

The low alloy steels that are being used more and more (with specially applied oxidation-resistant paints) are machined readily. No problems have been encountered when using standard tooling.

Turbine

In the turbine section itself, there is found a wide range of materials—from



8. Multiple tool set-up for turning four diameters simultaneously on Discaloy turbine disc. Machine, Gisholt Fastermatic; speed, 36 to 56 rpm; feed, 0.006 to 0.008 inch/rev. tool, carbide (C-2).

low alloy steel and Cr-Ni stainless steels to the non-machinable cast Stellite 31 alloy. This extreme variance in material, figure 3, is based on the temperatures and stress conditions found in the turbine.

The housings and liners operate at temperature in the order of 800 to 1100 degrees F (exclusive of hot spots), and at low stresses, the turbine discs operate at temperatures of the same magnitude but are subjected to much higher stresses. The turbine blades are subjected to both high temperatures (up to 1600 degrees F average) and high stresses. The stationary turbine vanes are only moderately stressed but are subjected to very high temperatures (1800 degrees F).

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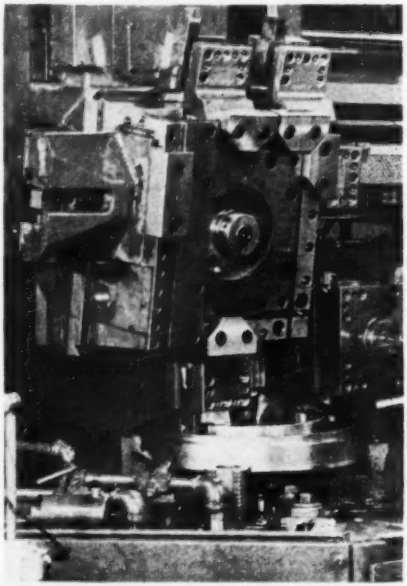
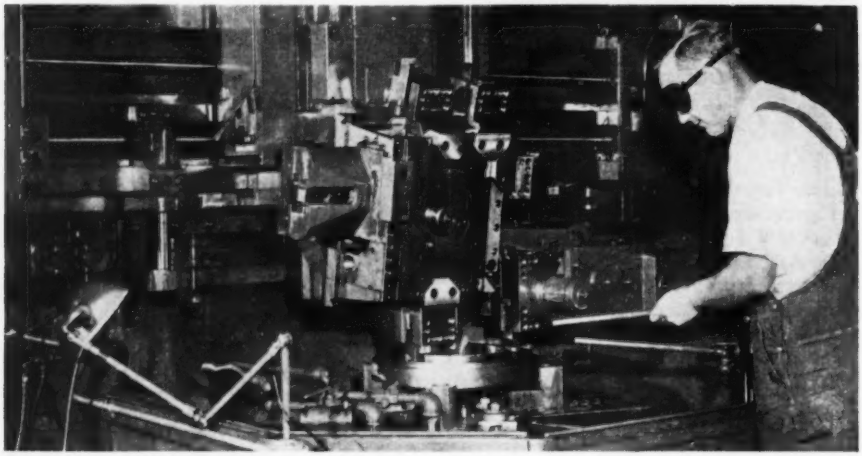
The turbine housing, liners, and nozzle shrouds are usually made from the 25 Cr-20 Ni (AISI 310) alloy. The machining of this material has been discussed in the preceding section. The chief problem is found in final machining because of the thin sections and large diameters. Considerable attention is directed toward tool condition. A dull tool can cause trouble. Recent metallurgical and design developments will result in going from this alloy to lower alloy content materials and in some cases titanium alloys. These changes will necessarily reduce the time required to machine the part.

The turbine vanes and blades are usually (investment) cast resulting in a minimum of machining time. This is fortunate since the assigned materials —Hastelloy C Refractalloy 80, and Stellite 31—must be ground to achieve production rates. The latter alloy is used for rotating turbine blades. The root, in this case, is formed by crush grinding. Grinding speeds, feeds, and table travel vary with the type of machine used. By proper selection of the right combination of oil and wheel it is possi-



9. Multiple tool set-up for turning, boring, counterboring, and chamfering Discaloy turbine disc. Machine, Bullard Man-Au-Trol; speed, 36 to 50 rpm; feed, 0.007 inch/rev. tool, carbide (C-2).



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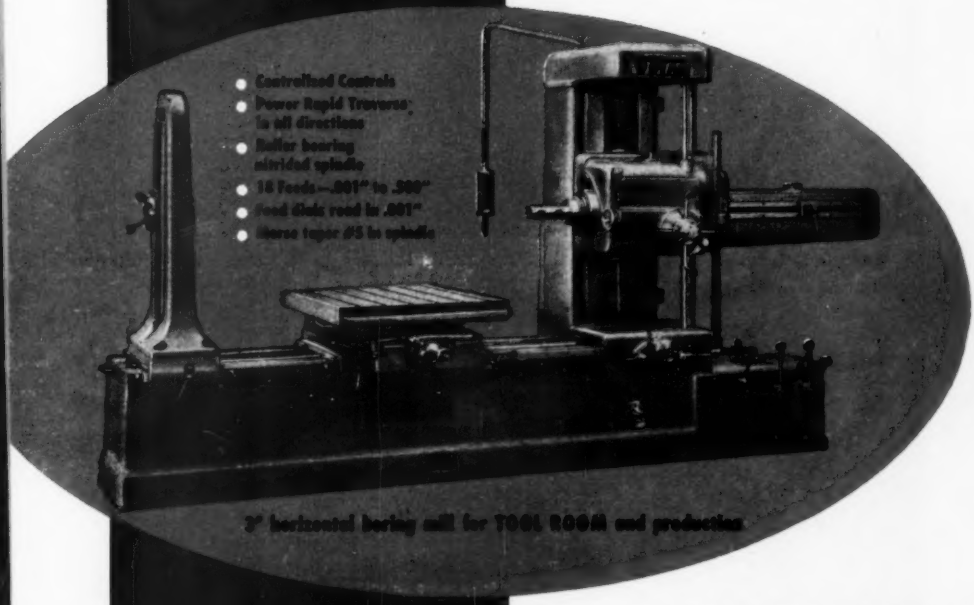
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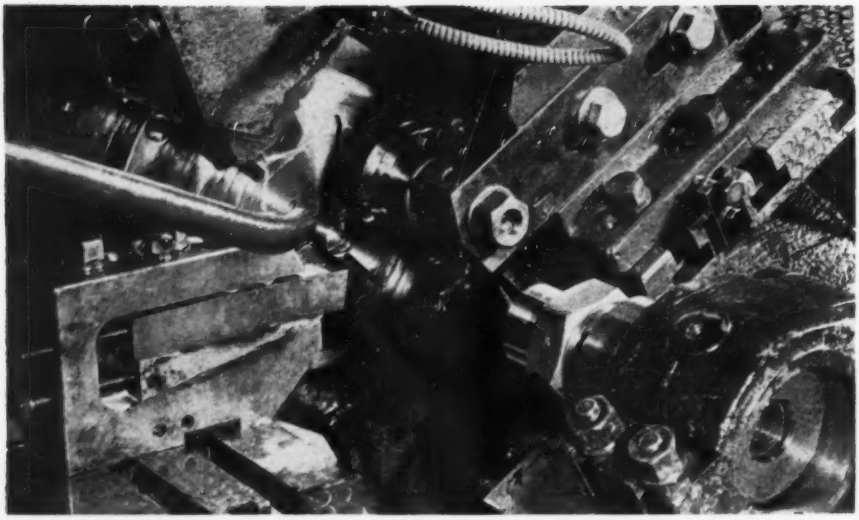
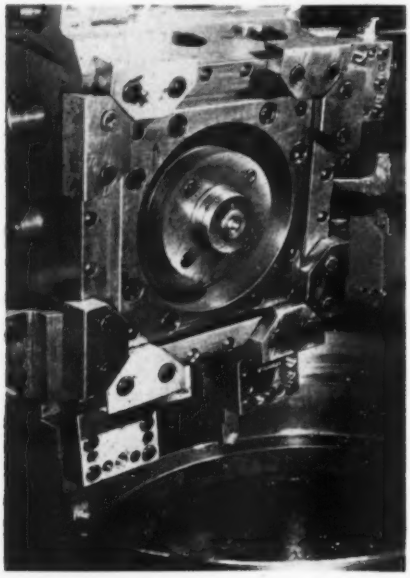


10. Multiple tool set-up to face, drill, turn, chamfer and cut off steel insert for light alloys. Material, AISI 431 (AN-QQ-S-770, Cond. QT C1 II); machine, Acme-Gridley; speed, 361 rpm; feed, 0.0047 inch/rev; tool, high-speed steel.



11. Multiple tool set-up to turn, face, bore, groove, and chamfer steel (AMS-5651) turbine housing. Machine, Bullard Man-Au-Trol; speed, 16 to 24 rpm; feed, 0.0026 to 0.007 inch/rev; tool, carbide (C-2).

ble to avoid burning and grinding checks to which this material is vulnerable.

The turbine discs and shafts are made from a Westinghouse-developed alloy, Discaloy. This material has good machinability (in the order of 25 Cr-20 Ni) despite its high inherent mechanical strength. Discoloy, in the solution-treated and aged condition, has a BHN hardness of 238 to 302. In figure 7 data are tabulated pertaining to the machining of this material.

Afterburner

The afterburner resembles the com-

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bustion chamber in its machining as it is a group of cylindrical components, flanged and bolted together. Because of the very high temperatures involved, materials such as Discaloy, Inconel X or W, and Type 310 are found. Of these alloys only Inconel X and/or W have not been discussed.

These high nickel alloys are as close to being non-machinable as any wrought nickel-base alloy known. The material when found in the engine is in solution-treated and aged condition. In this condition (approximately BHN 313), it is only possible to make finishing cuts and drilling is very difficult. For this reason, the afterburner is left in the solution-treated condition (approximately BHN 265) until the final assembly.

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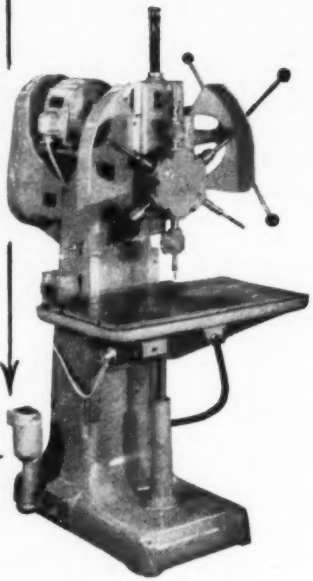

Illustrated is a Burgmaster Drill equipped with a Gusher Coolant Pump. Photo, courtesy Burg Tool Co.

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In this latter condition, Inconel X can be rough-turned at 50 to 80 sfpm with a feed of 0.010 to 0.015 ipm while finishing operations are performed at 35 to 60 sfpm and feeds of 0.005 to 0.010 ipm. Drilling operations are difficult. Cobalt hss drills should be used with slow speeds (10 to 25 sfpm) and heavy feeds.

Conclusion

A jet engine is composed of a wide range of materials—from those machined at the maximum speed capability of the tool to materials that are machined at the minimum speed capability of the tool. The metallurgist is the one engineer who can help machine shop personnel in the handling of these alloys. He can alter heat treatments to allow machining of a component in its optimum condition and in some cases he can

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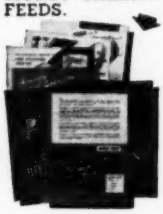

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CASE HISTORY No. 419

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The problem	A single grade of wheel was needed that would handle a wide variety of sizes and types of stainless bars and tubes. Normally, several grades of wheels would be specified, but the quantities involved would make this usual procedure uneconomical.
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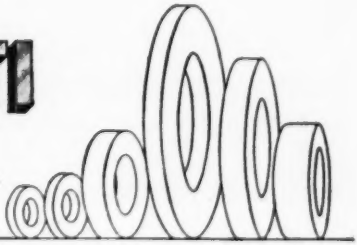
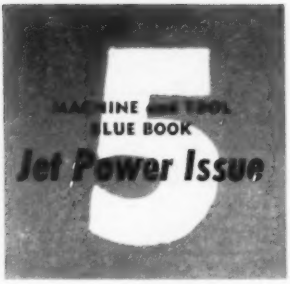




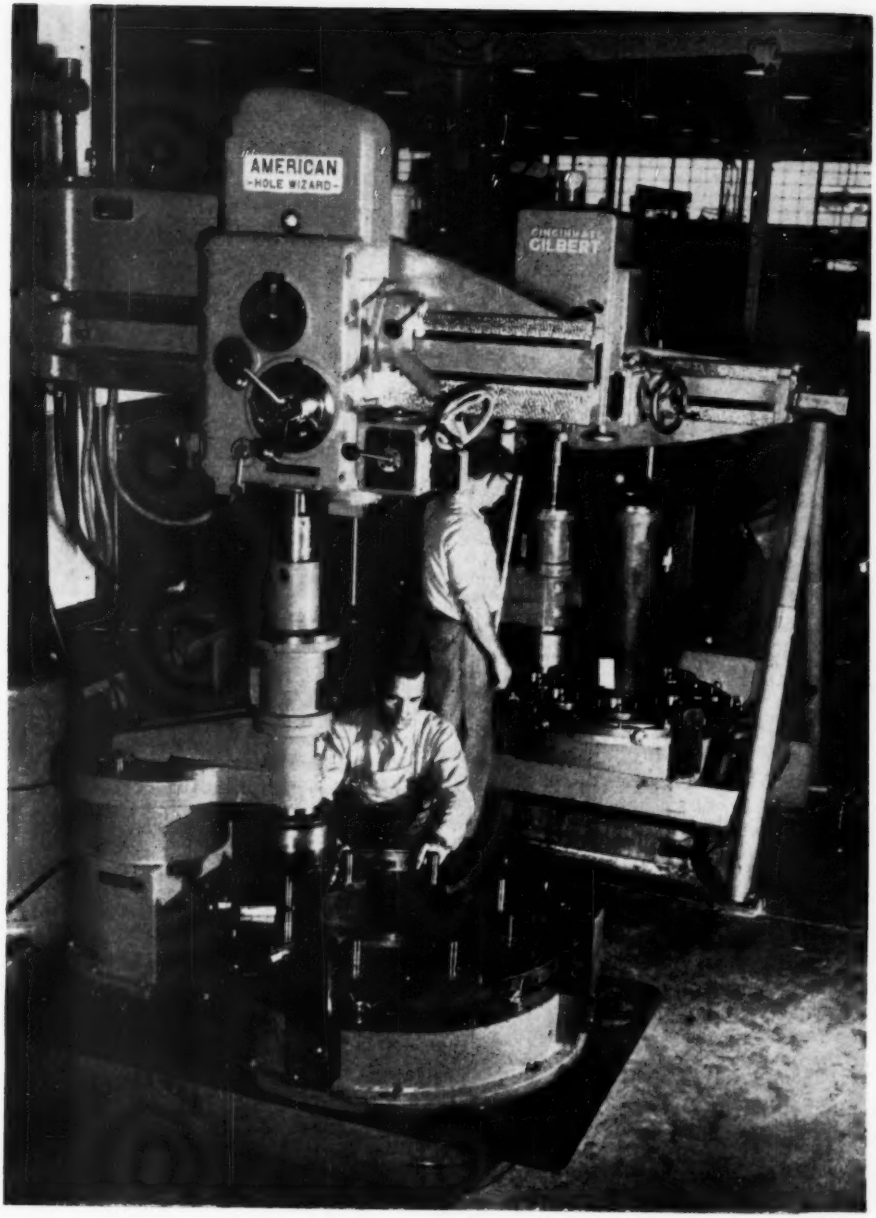
Tooling and Welding Aft Frames at Ryan Aeronautical

● THE AFT FRAME may be thought of as the "backbone" of the "hot end" of the jet engine. It is the structural member which holds the seething combustion chambers, transition liners and turbine and compressor cases together. It contains the housings which support two main bearings of the high speed turbine-compressor shaft.

All component parts for the aft frames are pressed out in steel dies, thus eliminating practically all handwork such as sawing and filing. All parts of the aft frame are joined together by precision welding methods with no other means of attachment being used. Sixty-four feet of electronic seam welding are used to form the barrel alone; more than 75 feet of manual metallic arc welding is employed to attach the five major flanges to the barrel and to join other details.

Welding requirements are high. The large circumferential welds must be accomplished manually, with well widths controlled within 1/16" and parent metals

At the right: Two of the fixtures used on radial drills which save 90% of the man-hours required over other precision boring methods. Eight "eyelets" and flanges must be machined to tolerances of .005" and finishes of 63 RMS microinches. The work involves precision boring, turning, facing, and undercutting of flanges.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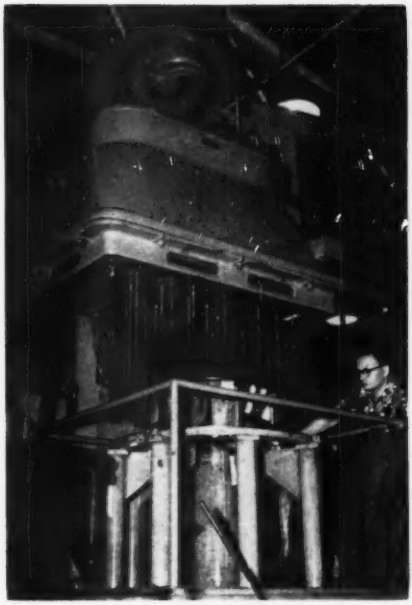
Because they are large, contain many mating surfaces and incorporate close dimensions, the aft frames require many machining operations with the majority of surfaces finished to 63 RMS microinches.

Of interest in one of the machining operations is a special piece of tooling on a number of radial drills. The work involves the precision boring, turning, facing and undercutting of the flanges which support combustion chambers in the aft frame. Each large aft frame contains eight "eyelets" and flanges which must be machined to tolerances of .005" and finishes of 63 RMS microinches. The fixtures were designed by Ryan engineers and each aft frame can be machined in only two hours with the fixture, realizing a saving of nearly 90% in man-hours over boring mills, had they been used.

The Ryan fixture consists of two units; a boring head and holding fixture. The vertical spindle of the boring head is actually a shaft within a shaft which is attached directly to the radial



A new Natco multiple spindle drilling machine which drills 160 precision bolt holes in the burner plate, adapter plate and bearing housing. The machine cuts a three hour drilling job down to 15 minutes. Forty holes are drilled at one time.

arm drill by means of a shear pin. At its other extremity it is fitted with a circular cutting head which holds four sets of dual carbide-tipped cutting tools. Each pair includes a rough- and finish-cut tool.

The holding fixture is a heavy cast iron assembly which rigidly holds the aft frame and rotates on ball bearings to permit indexing of the unit.

Using the radial-arm drill as a source of power and feed, the boring head spindle rotates and descends automatically bringing the cutting head into contact with the flanges. The first pair of cutters bore the inside diameter of the flange. When this operation is com-

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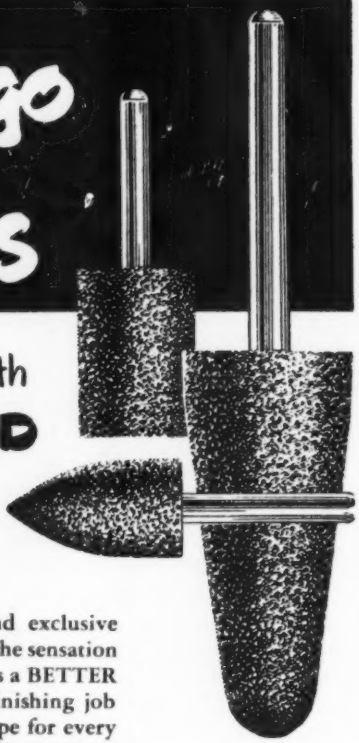

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pleted, the further descent of the head brings the second cutters into action to turn the outside diameter. Care is taken to insure that these machining operations do not overlap so that vibration from one will not interfere with the other.

When the turning is accomplished, the outer shaft descent is stopped by a pilot and the inner shaft continues to descend. This actuates bell cranks which move a third pair of cutters, horizontally, to face the top of the flange. Then, the last cutters are brought into play, by cam action, to undercut the flange on a bevel.

Since each operation of the sequence follows in rapid order, exact timing of the action is necessary. This is obtained by a special Ryan-devised system of timing pins which are grooved into the shafts to positively coordinate the motion of the parts.

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and the operator is required only for loading and unloading the machine and indexing the aft frame. Swinging cranes, with air-operated hoists, are located at each machine so that one man can perform the loading. The radial drill arm and boring head are easily swung to one side to allow room to load the holding fixture. Water-soluble oil is pumped to the cutting head, from a collecting reservoir, to remove heat generated by friction.

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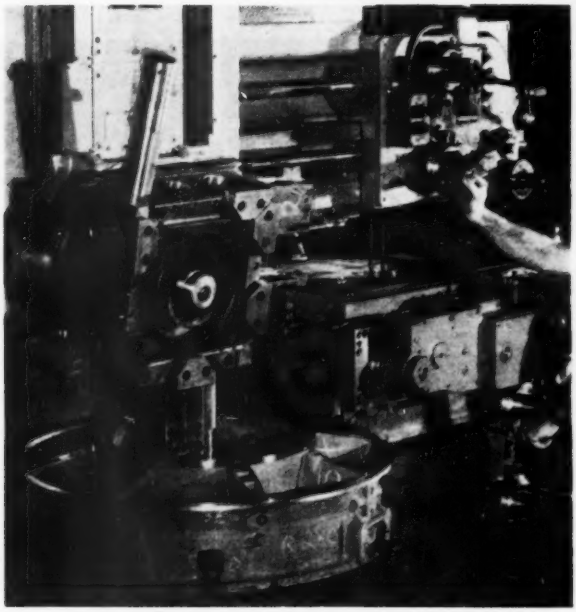
Prime Contractors and Sub Contractors Produce Jets and Components

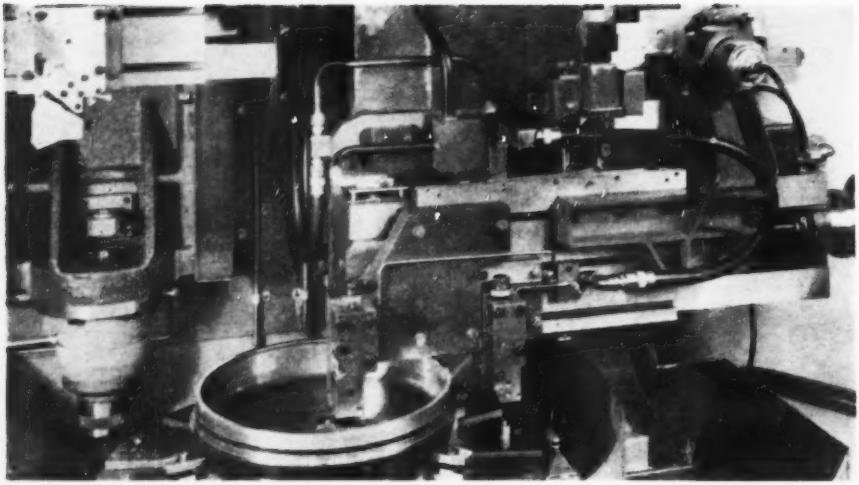
●INCLUDED HERE are a few shots of machines and operations gathered from various shops around the country. Governmental restrictions have become so tight in the past years that considerable machining information had to be deleted. Literally hundreds of photos and installation texts have been classified restricted. Names of manufacturers in many cases must be withheld.

Some of the photographs were taken at Bridgeport-Lycoming Div. of Avco Mfg. Co. In 1951 the Bridgeport-Lycoming plant was 1½ acres of nothing, the empty Chance-Vought plant. Today there are 5,300 employees in an efficient well-run establishment. B-L turns out jet components as well as 50 to 400 h.p. opposed cylinder aircraft engines, 500 h.p. tank engines, and 1425 h.p. radial engines.

Practically every machine tool builder and manufacturer of accessory equipment is represented in jet manufacturing plants. It will be appreciated that it is patently impossible to show photos of every piece of equipment in this story as well as in the other articles; it is hoped, however, that a representative collection has been compiled at the end of this issue.

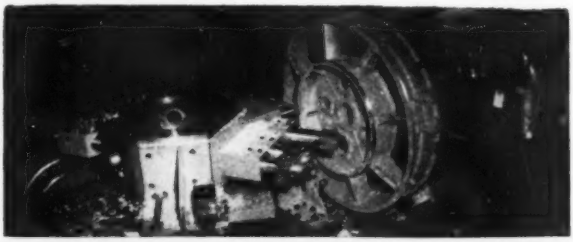


Vertical boring machines face, turn and bore cast magnesium front frames. This is a battery of Ex-Cell-O's. They have two hydraulically operated tool slides that function in sequence according to a pre-established style. Rheostats permit selection of most efficient spindle speed for use with each slide. The speed change occurs automatically as one slide completes its cycle and the second cycle starts.

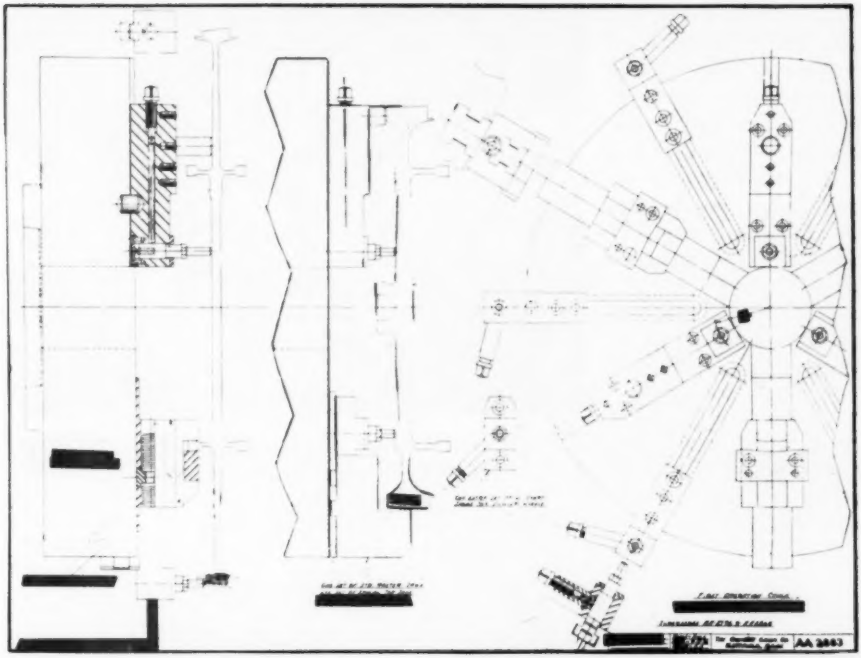


In this setup the contouring slide carries three tools. The first cuts the contour on the web from the central hub to the outer flange, the second continues up the inside of the flange, and the third turns the O.D. Five tools in the left-hand slide clean up faces and fillets on the outside of the flange, chamfer an edge and face the flange. Right tool slide is tracer controlled. Note stylus, upper right of photo.

Here is a front compressor housing being machined on a W & S turret lathe which has been gapped out to permit the larger swing. The machine is without the cross slide unit and with a cross sliding hexagon turret.



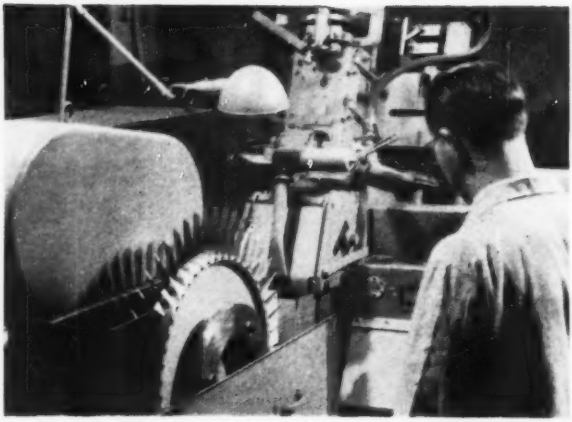
Directly in front of the compressor section of a modern jet is the front gear and frame assembly which drive the accessories. Cast magnesium is the metal for the frame while the cover is of aluminum. Work is performed on two-spindle automatic machines.

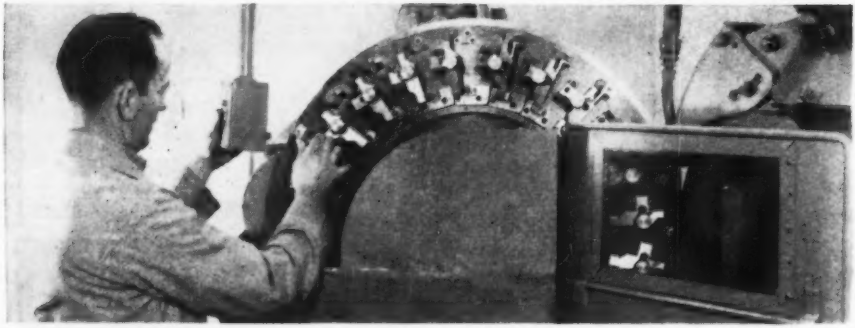


Many interesting chuck designs are in use for holding the thin, yet large jet components. Shown is a drawing of a Cushman chuck for the holding of turbine wheel components. This first operation chuck is a 3-jaw self-centering chuck in which the self-centering jaws are lightly gripped in the O.D. of the skirt of the workpiece. Upon each self-centering jaw is a jaw having an adjusting screw which permits these latter jaws to be securely locked against the workpiece directly opposite the grip already lightly taken by the self-centering jaws. Thus the grip of the jaws does not distort the workpiece.

Machining stainless steel jet engine nozzles with "Kennamatic" tool having vertical indexable insert.

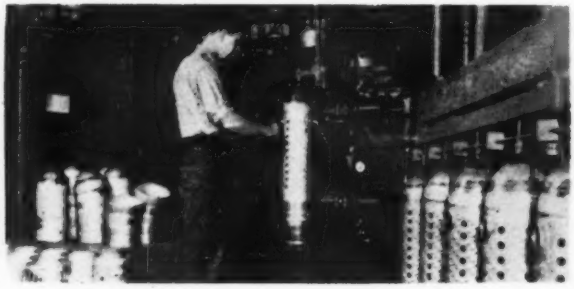
Discs and wheel grinder, by Norton, is here adapted for grinding the ends of blades. A feature of this operation is the mounting of the parts on the workhead face plate. In this operation the blades are mounted on the compressor wheel rotor which is mounted on the workhead face plate and held by a circular magnetic chuck.





Surfaces and radii of the root tang on second stage turbine stator blades are being ground on a special Cincinnati with special tooling. Limits within .0005" must be held on flatness, straightness and parallelism. Twenty-four blades can be ground at once. On the root tang 5 surfaces and 2 radii must be ground. The machine makes possible the accurate machining of the 16.075" and 15.475"radii on the surfaces. A free-cutting wheel is used. Material is Nimonic 80.

Especially designed for inner combustion chamber fabrication, this new spot welder makes four spot welds at a time and automatically aligns the chamber shell, cap and exit shell. Thirty-two spot welds are made in a matter of minutes to form this assembly, which is seam welded later.



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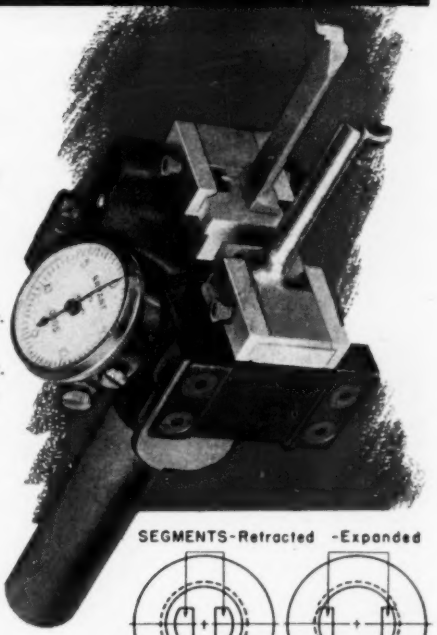
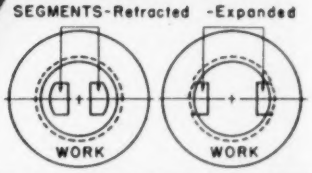
Actual checking of the groove is done by a pair of segments mounted on platforms, one of which is movable. A thumb lever collapses the movable, spring loaded segment so that the gaging members may enter the work. Release of the lever permits the segment caps to expand into the groove. The movable segment actuates a precision dial indicator which shows variation from basic size. An indication of groove roundness is obtained by rotating the work part on the segments, or by rotating the gage in the work.





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- Four pairs of segments cover standard "O" ring grooves from 1/16″ to 4 1/8″ dia.
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A Lodge & Shipley T-lathe is machining a rotor compressor wheel, 12th stage. The operation consists of contour facing in two passes in stainless steel material. Cemented carbides are used with a feed of .015/rev., at 150 ft./min. Machining time is 54 minutes.

A Bullard is used by Ryan Aeronautical to machine the flanges of jet engines exhaust assemblies.

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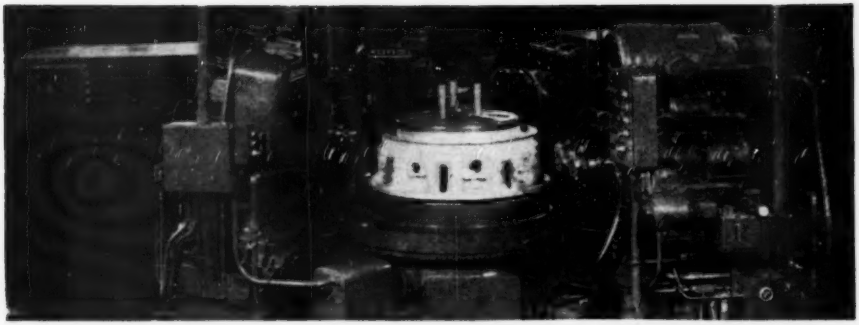
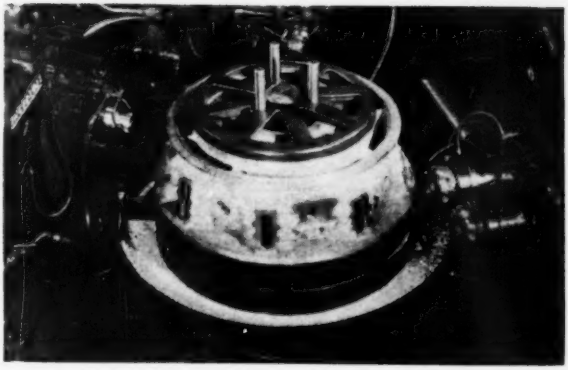
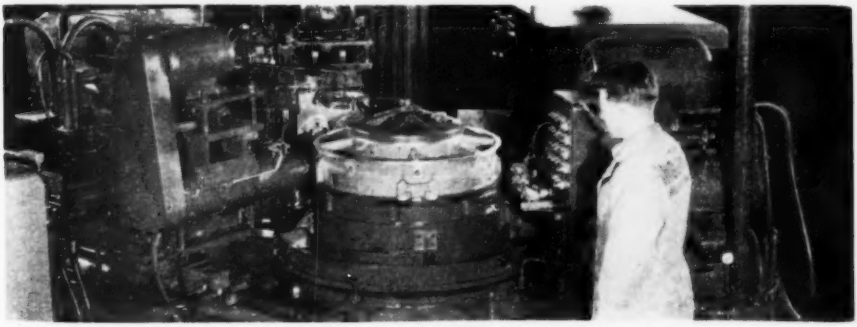


This Ingersoll rough and finish mills 12 pads on the periphery of aluminum rear compressor frames for jet engines. Production is 6 frames per hour at 100% efficiency. The machine bed carries an index table 36" in dia., which is hydraulically indexed to 8 positions. Bed wings located around the table contain the heads, all of which feed horizontally, and two of which also travel vertically on knee type ways. Ingersoll mills with carbide-tipped inserted blades are used for both rough and finish milling.

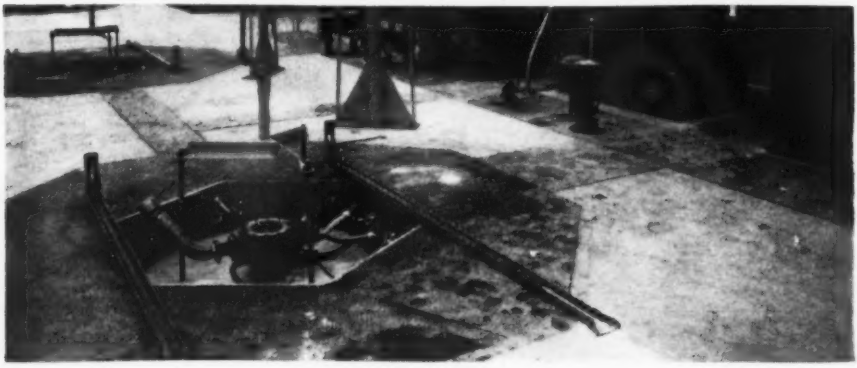


Sixteen pads on the periphery of magnesium compressor frames are rough and finish milled at 6.7 frames per hour at 100% efficiency.



The Wharton system of tooling consists of approximately 450 basic pieces which are used to assemble jigs and fixtures for machining and assembly work. The set is composed of interlocking blocks, clamps, bolts, bushings and other parts which can be assembled in an almost infinite number of combinations.

A spintesting pit for the testing of turbine wheels. Spintesting is done in a pit under accurate operating conditions. Induction heating coils are placed around the pit in such a fashion that the rim and blade temperatures are raised to 1000-1500°F, while the hub and web are kept cool by water jet. Spintesting machin is made by Warren Brothers Roads Company.



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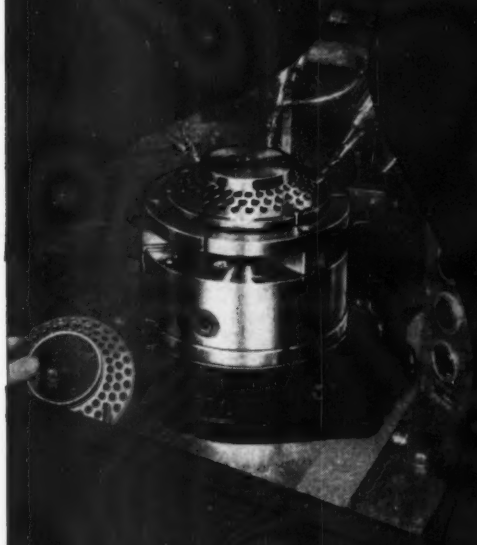

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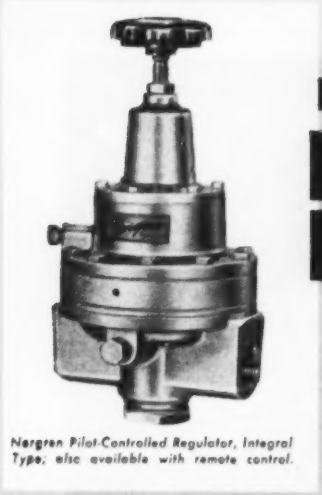

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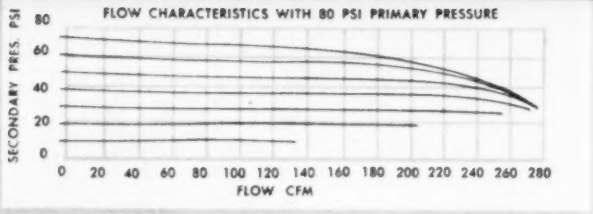

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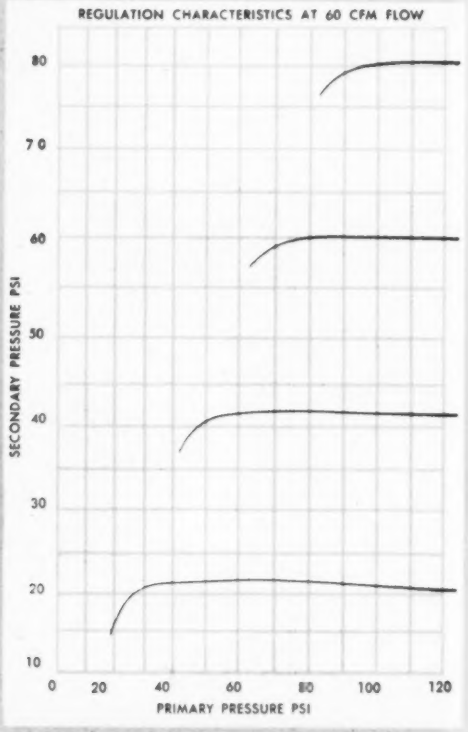

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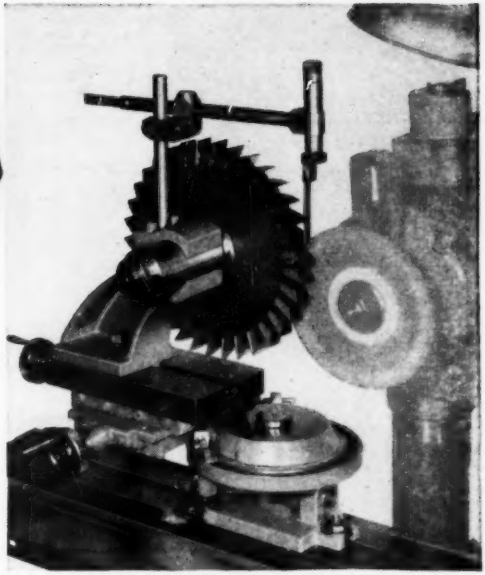

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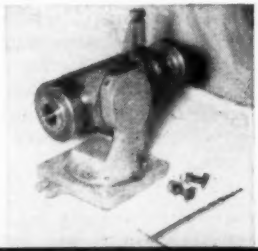

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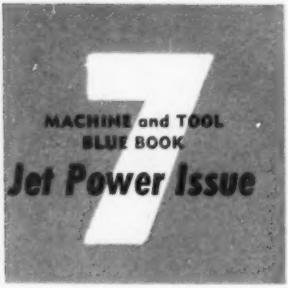


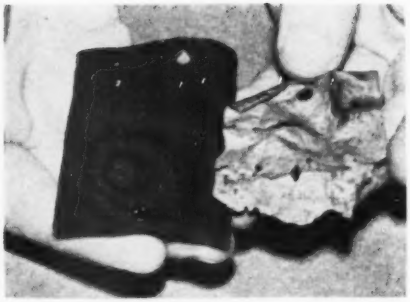
Conserve Critical Materials By Ceramic Coating of Jet Engine Hot Parts

By **J. V. Long**
Director of Research
Solar Aircraft Co.
San Diego, Calif.

THE METAMORPHOSIS from Whittle's first crude gas turbine into today's high thrust power unit has been accomplished only by monumental effort in the field of metallurgy. Materials have been invented and perfected which withstand long-time operation at temperatures of 1500° or perhaps slightly higher. Unfortunately, the elements so necessary to the development of the highly heat resistant alloys are not available in the quantities necessary to meet production schedules. It is this scarcity of alloying elements, and the role of protective coatings in making possible the substitution of lower alloys at high temperatures that I wish to discuss.

There seems to be a reluctance on the part of designers and manufacturers to utilize less strategic materials to the maximum extent possible. This probably is due to the fact that we always have had an abundance of materials and it is difficult to realize that we are a "have not" nation in so far as many of the elements necessary to our super alloys are concerned.

Because jet engines use an enormous amount of critical materials which are extremely scarce in the U.S. it is absolutely essential that substitute materials be discovered. Ceramic coating of low alloys has met with some success in imparting high temperature characteristics to these alloys, resulting in a saving of critical materials.



A dramatic example of the protection afforded by the Solaramic Process against jet engine temperatures. Two thin samples of AISI Type 321 stainless steel were tested at 1850 F. The piece at the left, Solaramic coated, is shown after 150 hours of testing; the uncoated sample at the right was virtually destroyed by oxidation after only 20 hours.

One of the most effective methods of conserving critical and strategic elements, without curtailing production schedules, is to substitute ceramic coated lower alloys for the alloys now used.

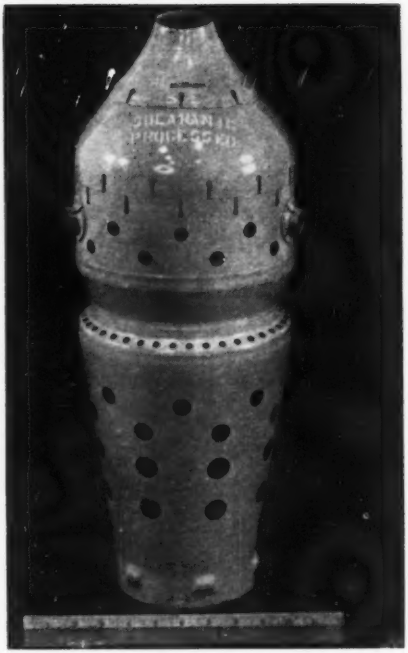
A broad program was begun in 1942 when the government decided that exhaust manifolds for military aircraft could be fabricated of such low alloys as AISI Types 1010 and 1020 steels protected with standard porcelain enamels.

In 1947 our designers were working on the development of a small 200 hp gas turbine. They even offered to modify the liner if it would facilitate fabrication and coatings. After studying the design, our metallurgist said that 1010 or 1020 steel **might** have the structural strength for satisfactory operation up to a temperature of 1500°, if the surface was properly protected from oxidation.

Our first liner was fabricated of the same gage and to the same design as the original stainless part. The liner was of .032 sheet, and after 4 hours of operation distortion took place due to lack of structural strength. We consequently made a study of critical radial pressures that could be applied to a cylinder of unit length without causing deflection of the wall. Cylinders of 321 stainless and 1010 mild steel were studied under conditions which included a temperature of 1500° F, the operating temperature we had chosen for our tests.

Since a liner fabricated of 321 with a wall thickness of .032 gave indications of satisfactory operation, we checked our liner radius of 2 inches against the wall thickness and found a

After coating these thin sheets of AISI Type 321 stainless steel can be bent and crinkled repeatedly without fracturing the coating, one of the unusual qualities of the process.

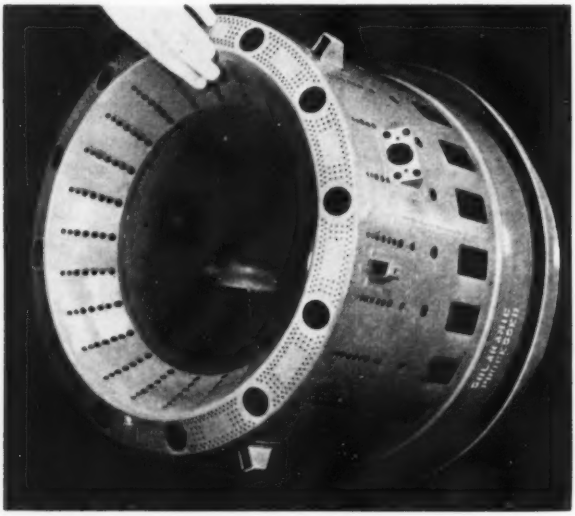


This is a jet engine flame tube processed by Solar Aircraft Company to protect the metal—nimonic 80—from heat and corrosion. This flame tube is used on the Svenska Flygmotor Ghost jet engine.

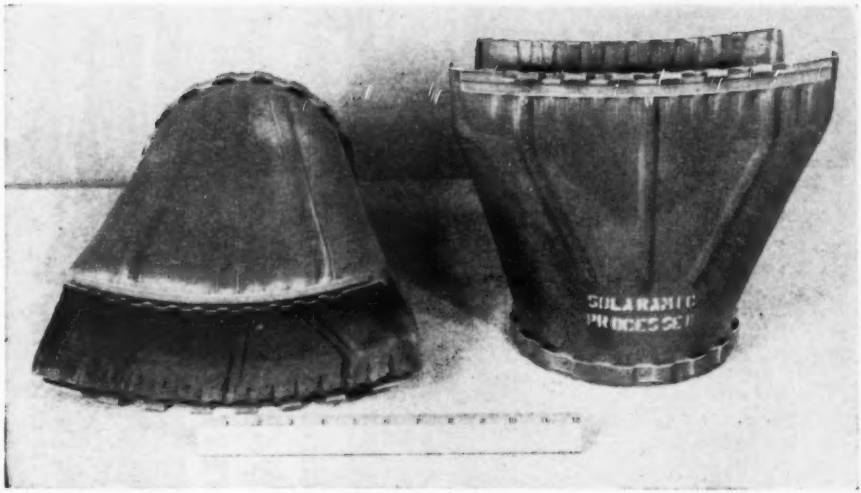
hypothetical pressure of approximately 20 psi. We found that to withstand the same hypothetical pressure, the 1010 liner would have to be formed with an 0.48 wall thickness. We made a liner with an .050 wall, coated it, and it worked.

The success of this small turbine liner suggested investigations of mild steel substitute liners for larger engines. Tests proved the liner was adequately protected by the Solaramic coating and had the structural strength to operate for long periods at temperatures which finally reached 2000°F. We believed we could be just as successful with liners for the big J35 or J47 engines.

We were overly optimistic! There is quite a difference in the sizes of the

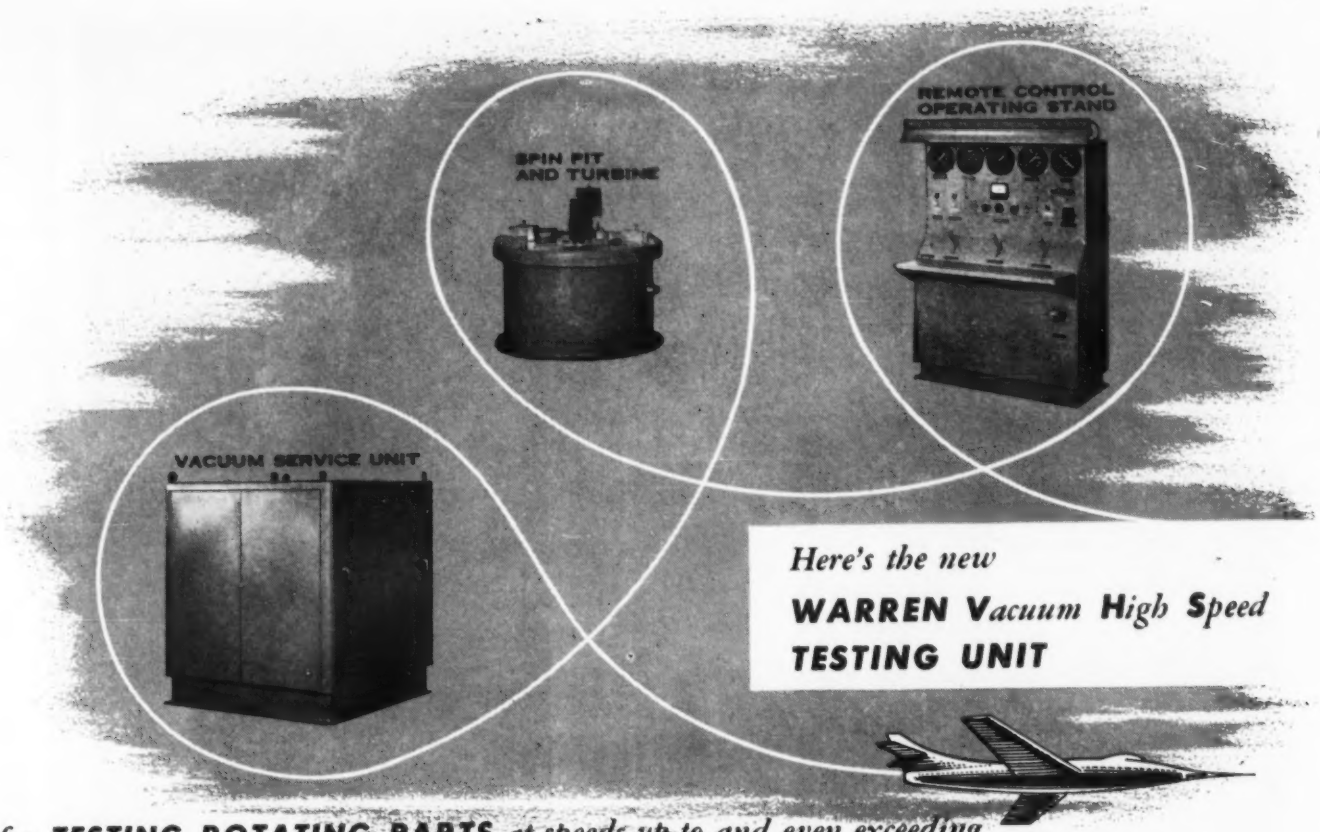


This is a burner basket used on the J44 jet engine for missiles. It is fabricated from Type 321 stainless steel and must operate at temperatures as high as 2000 F. It has been ceramic coated to extend its service life under these extremely high temperatures.



These are transition liners used on the J47 jet engine. Solar Aircraft Company is ceramic coating volume quantities of both transition liners and combustion chambers for jet engine use.

Large quantities of combustion chamber liners are being ceramic coated by Solar Aircraft Company in San Diego, California, to extend their service life under the extremely high temperature conditions of jet engine operation. These chambers are being processed in Solar's pilot plant; the company has also recently installed mass production, conveyorized coating facilities for combustion chambers and other jet engine components.



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Model 80 liner and a J47 liner. We just had not appreciated what that difference in size meant.

We encountered our first difficulty in firing the coating on the big liner. At the firing temperature, the mild steel had insufficient stability and the liner warped and sagged. Special jigs solved that problem, but you can't put special jigs in a jet engine, so the first liner to go into a type test lasted just 12 hours before failure.

It seems to me that the failure of this liner strongly points out the absolute necessity of complete cooperation among designer, metallurgist, manufacturer, and ceramist.

In the case of the Model 80 liner, we had all of these men at one work table. Most of the factors were available for evaluation, and careful study of the entire problem by each member of the team resulted in a successful achievement.

On the other hand, our work on the big liner was seriously handicapped by the lack of an important member of the team—the designer. We had to take a design developed for Inconel fabrication, and practically hearsay reports of working conditions and temperatures. These factors were unknowns we could not solve for, and failure was the result.

However, we had gained important data. We now knew that our coating would inhibit or eliminate oxidation. Therefore, if we could find an alloy lower than Inconel, but mechanically as strong, we could make up a deficiency in resistance to oxidation with high temperature ceramic coatings.

Our next approach was a liner in which the inlet and outlet ends were fabricated of higher alloy with the body section of mild steel. Since during operation the inlet is the cold end, use of Inconel here would at first appear to be a waste of strategic material, but the added strength allowed us to hang the liner to fire on the coating, and no furnace sag or warp occurred.

What might be termed a partial success was the liner in which the body and cap were of AISI Type 4130, with only the exit end of Inconel. This liner logged 186 hours of operation in a J47 engine with only minor warping caused by hot spots.

Because we were not too happy with the results of the 4130 trial, we decided to use AISI Type 321 stainless steel for our next test. This proved a good choice. Protected with a Solaramic* coating, liners of 321 in type test competition with Inconel liners, not only surpassed the standard service life, but were capable of further service after several of the Inconel liners had reached the failure point.

*Trade-Mark: Patents Pending

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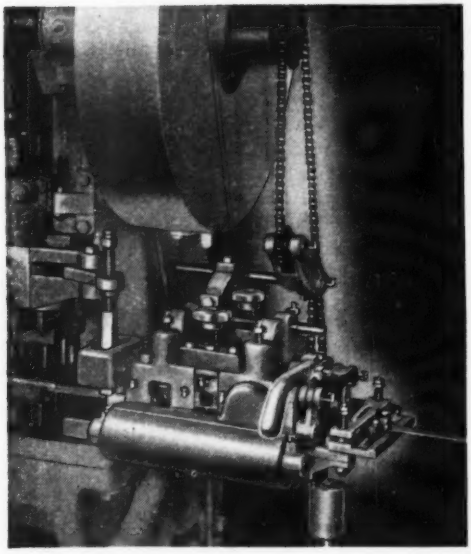

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So successful were the tests that we tackled another super alloy problem, the turbo-hoods for reciprocating engine turbo-super-chargers. These hoods were of N-155, a material which has a high strategic metal content and which presented difficult problems at every state of fabrication. From what information we had available, we decided the design and working conditions made the use of ceramic coated 321 feasible. Again we were successful, and today our production lines are rolling out quantities of these ceramic coated 321 parts which are providing service life equal to or better than before.

Another application where we helped to save additional critical materials was the turbo-supercharger nozzle box. Here we replaced AISI Type 347 with Solaramic processed AISI Type 321.

This job is an interesting one because it shows what cooperative effort can do. We not only manufacture these units but we also ceramic coat them in our own plant.

The first experimental units were coated and fired after finish machining. This caused a large amount of warping. While our customer was attempting to obtain Air Force approval of tolerance deviations, our manufacturing people and ceramists got together and solved the problem. The solution! Coat and fire before finish machining. In other words, integrate the manufacturing processses with the coating so that tolerances can be met.

A great deal of interest has developed recently in a low alloy steel known as NAX. Although this material is a poor substitute for stainless steel, we have achieved excellent results by protecting NAX parts with our low alloy coatings.

Uncoated low alloys deteriorate rapidly at lower temperatures. At 1300° F, coated mild steel showed no deterioration during the 160 hours of test time. The uncoated metal picked up an immediate oxide coat during the first 10

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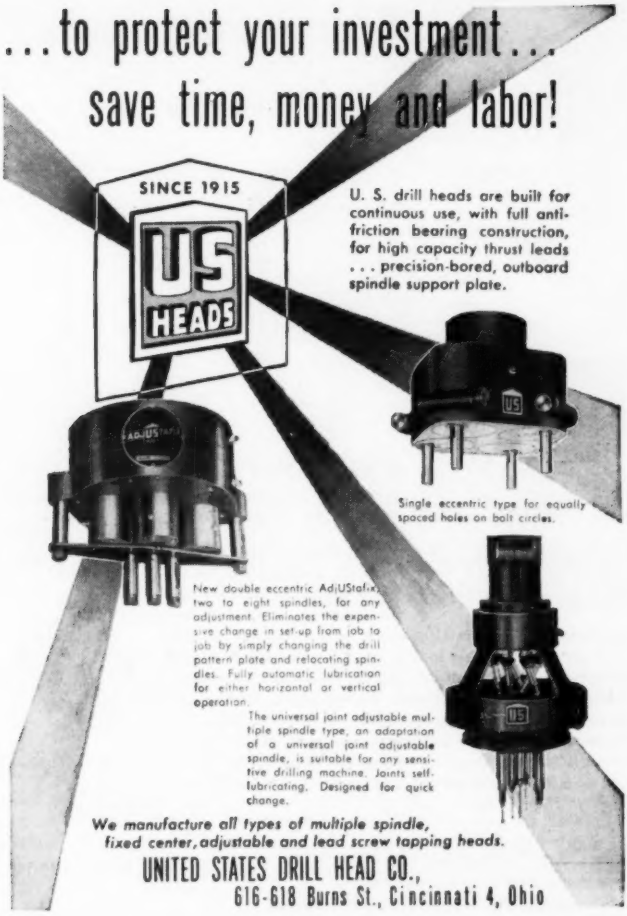
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hours, then began to fail rapidly.

With a growing background of design and metallurgical knowledge, we decided the time had come for a complete re-evaluation of our conservation efforts. We had conserved scarce metals by substituting coated 321 for N-155 and Inconel, but we knew we could do better. So we studied the creep and rupture strengths of alloys between AISI Type 1010 and AISI 321. Alloys like AISI Type 502 Ti might be the answer. They have more strength than 1010 which failed, and less strategic elements than 321 which worked.

Such materials as AISI Types 501, 410 and 430 were subjected to a long series of laboratory tests in the hope that they could be used. Although these alloys showed promising characteristics, we found that they were difficult to fabricate, because all are air hardenable. We developed excellent protection with our coatings, but we knew we

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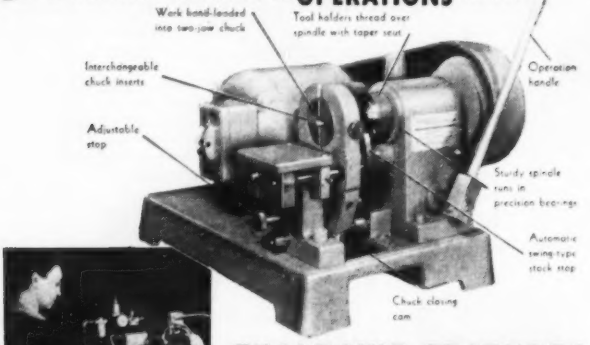
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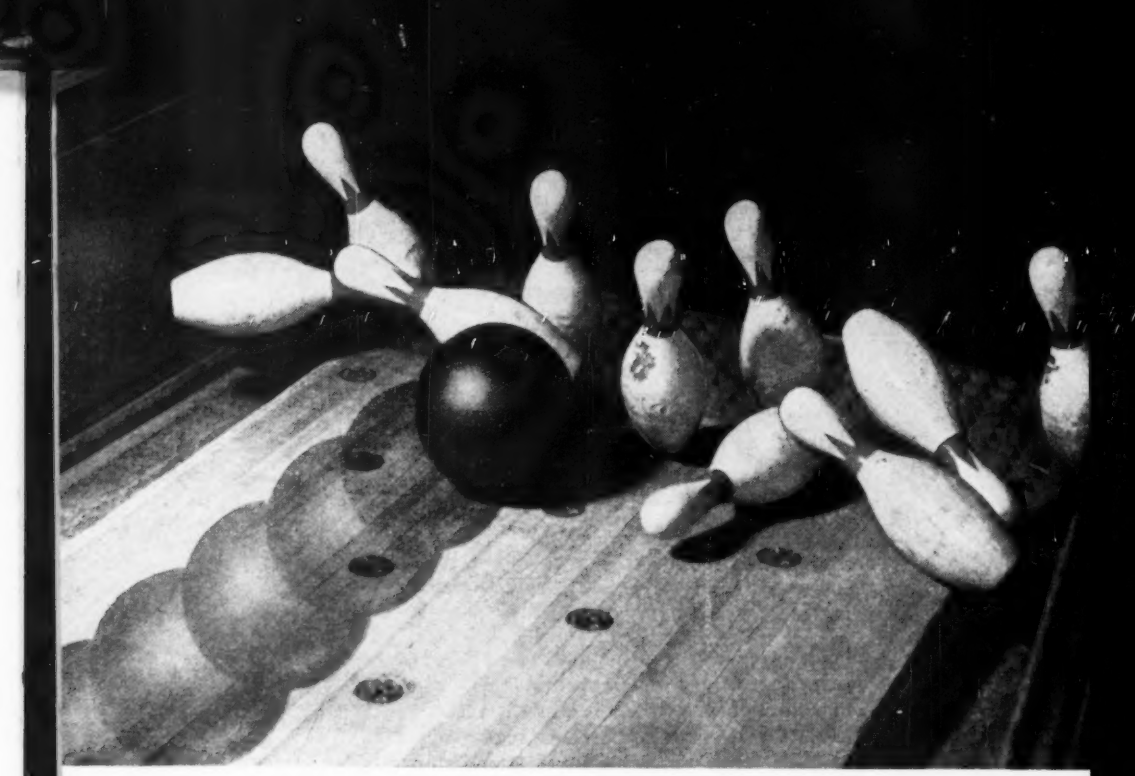
might have trouble fabricating parts.

For a time we thought that AISI Type 321 would be the lowest alloy for most jet engine hot parts. Recently, however, our test results with AISI Type 502, plus titanium, indicate that this alloy should permit further reductions in critical and strategic alloys. Laboratory tests on this 5% chrome alloy have been successful enough to warrant a proposal to the Munitions Board for testing liners and tailcones made of this material and protected with Solaramic. We also recently negotiated a contract for evaluating low alloy tailpipes and manifolds and AISI Type 502 was included. Although cooperation is not ideal because we do not have the design engineer as a direct member of the team, we feel important progress will be made.

However, it may not always be possible to replace a complete super alloy unit with one of a lower alloy. There-



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fore, consideration should be given to the possibilities of making combinations of the rich and the lean alloys.

An experiment of interest involving this principle was a transition liner. The stiffeners and wear pads are of AISI Type 310, (25% Cr and 20% Ni) while the liner body is AISI Type 1010. The fatigue failure, which occurred just below the stiffener band, resulted because the mild steel portion was fabricated to a design developed for a higher alloy. Modified design, for example running stiffener fingers through the failure area, quite possibly would provide a part capable of satisfactory service life with a substantial saving of strategic elements. Of course, following failure of this liner, the engine manufacturer reported the ceramic coating was inadequate. However, it is clear the failure is due to fatigue, and the ceramic coating definitely allowed the 1010 material to withstand operat-

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ing temperatures for an extended period of time. Without the coating, the metal would have burned away.

I believe this method of combining materials should be given more consideration by designers. I believe we know enough about metallurgy to predict which parts of a given fabrication could be made of a low alloy. Our manufacturing processes are advanced to the point where we can achieve satisfactory forming and joining of unlike alloys, so no serious fabrication problems should develop. For these reasons, such combinations are feasible, and even though we would not realize a 100 percent elimination of the critical and strategic elements, we would go a long way toward minimizing their use.

The End.

"Hot Parts" Manufactured by Mass Production Methods

By **B. A. Willsey**
Mgr. of Manufacturing
Solar Aircraft Co.
San Diego, Calif.

THE METHODS that are being used by Solar to triple or quadruple output of "hot parts" for jet engines in factory buildings that were already theoretically operating at capacity are not unique with Solar. What was done was to examine, with a fresh eye, the high production methods of mass output industries—such as automobiles or heavy appliances—and to adapt techniques, wherever possible, to the jet parts business. The unusual aspect is that, in recent months, we have virtually transformed the making of jet components from the "one at a time" methods of traditional machine shops to the mass production techniques synonymous with Detroit.

Here is how the program has worked out, taking the manufacture of General Electric J47 combustion chambers and transition liners as an example. Before we shifted to the use of high production machinery and conveyorized lines, combustion chambers and transition liners were turned out at the rate (in dollars of shipments) of $15.35 a square foot a month. Today the output rate per square foot of factory space is almost three times as high—$44.70 a square foot a month. And the present high production and conveyorized facilities could, if stretched to capacity, achieve a rate of $66.50 a square foot a month, or more than four times the old rate.

This production increase was not gained overnight, or in a simple manner. But mainly it involved changes in five basic aspects of production operations.

First: We shifted the jet parts departments to conveyorized mass production assembly lines wherever possible. These lines replaced the former practice of segregating operations, such as grinding or boring, by departments, figures 1 and 2.

Second: The company decided to use as many special purpose, high production machine tools as possible. Many of these were designed and built by the company itself, or by outside suppliers. Each unit contains in itself all of the special fixtures, tooling, and machining heads needed for a complicated sequence of operations, and each unit is automatic or semi-automatic.

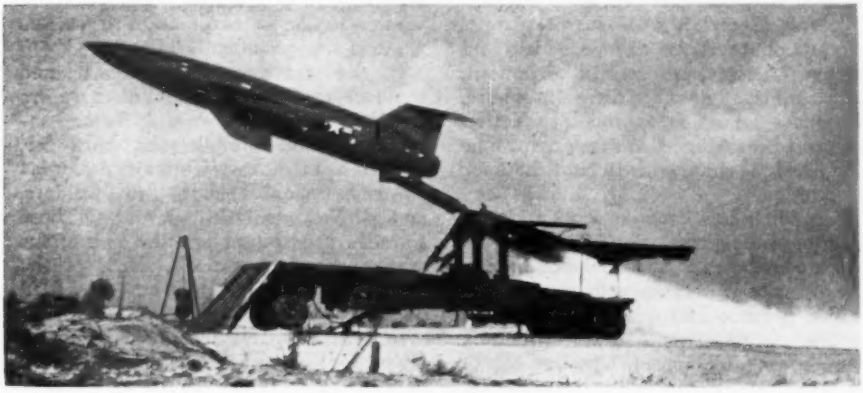
Third. Where standard high production machine tools could be used to boost output they were installed, such as multiple spindle drills, automatic chucking machines and duplicating lathes. While such machine tools are commonplace in many mass production industries, they have been used infrequently in the highly precise work on super alloys such as that turned out at Solar.

Fourth: We designed and built several new types of high production welding machines. These embodied new concepts of welding, and they have been so successful that firms as far away as England and Sweden have asked the company to make and sell similar units to them.

Fifth: We worked with new concepts of labor utilization and plant layout that have allowed the company to increase efficiency despite the serious shortage of skilled machinists, and, as previously indicated, to greatly boost output in dollars per square foot of plant space.

Before describing some of these changed methods and techniques in

The Martin B-61 Matador pilotless bomber is the initial equipment for the 1st Pilotless Bomber Squadron (Light) at the USAF Missile Test Center, Cocoa, Florida. The initial "push" is provided by a rocket, after which a turbo-jet engine takes over, the rocket dropping off. In addition to being radar tracked, visual contact with the Matador is made by chase planes. Details of performance have not been released by the Air Force.



1. Between three and five hours on each jet engine exhaust cone are saved by Solar's roller conveyor production line. A number of new high production machines are still to be installed in the line which will make the total time saving considerably greater.

greater detail, it might be well to outline the factors that influenced Solar's management in making the changeover.

First of all, quantities have been increased on certain jet engines—such as General Electric's J47—so that mass production methods are possible. And design changes, while still frequent, have simmered down to the point where, for example, an aft frame production line can be set up with some assurance that design changes will not hamper production.

Second, it has become economical to shift to mass production of jet engine parts. Shortages of skilled labor in San Diego make it necessary to recruit unskilled persons and quickly train them in one or two simple tasks—which is possible under a mass production setup. So Solar decided to begin changing its manufacturing methods to embrace jobs as simple and specified as possible, and to train men and women to fill these jobs. (Today at Solar-San Diego 46 percent of the production employees are women.) The attempt to hire skilled persons was practically abandoned.

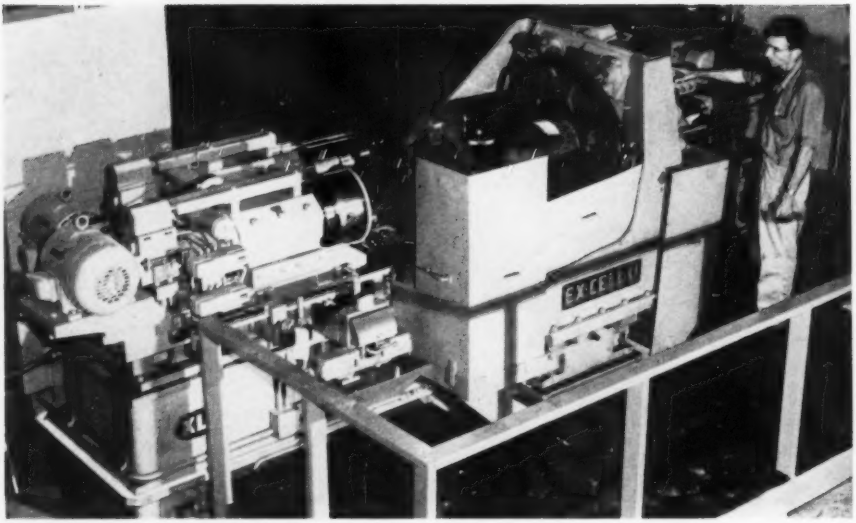
In the last year Solar has trained thousands of persons. Most of these are in the lesser skills—metal fitters, assemblers, and similar jobs. However, about 400 or more were trained as machinists, fusion welders, spot welders, and similar semi-skilled crafts. These trainees are taught specific operations or groups of operations. Most of the training is on the job—an unskilled person working with a skilled craftsman. But some classroom work is also given in certain categories. Trainees are paid for the training period.

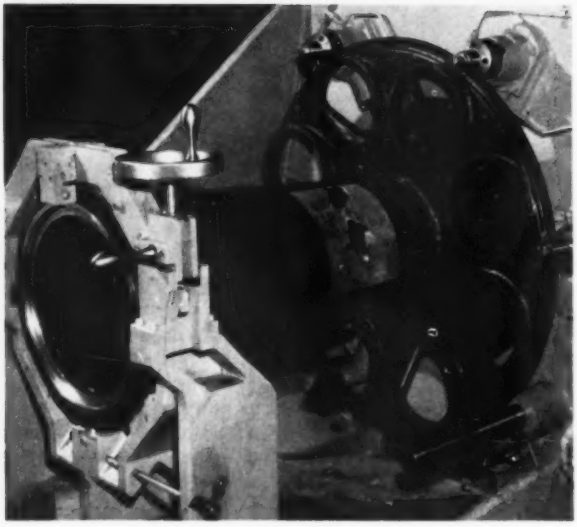
2. In the manufacture of "hot parts" for jet engines, Solar applies the mass production methods of the automobile industry to what was formerly a machine-shop type operation. One sample is the installation of mechanized conveyor lines, from which jet engine components emerge, ready for shipment, as fast as one every 2½ minutes.

While training for mass production operations is fast and highly specialized, it must be thorough, for Solar produces jet components of high dollar value and one small mistake can spoil a part worth hundreds of dollars. In addition production engineers provide foolproof tooling for machines and extremely detailed instructions for operators. The assumption is that, even after training, the operator is still inexperienced. Such precautions are taken as the use of locks in some machines so that the machine will not operate until the operator has it properly adjusted and set to go.

In practice, the jet parts revolution at Solar may be epitomized by briefly describing some of the new techniques and machines that have been introduced. Take the company's new transfer boring and facing machine for example, figures 3, 4 and 5. This 19-ton, $90,000 monster machine tool slashes 87 percent off the time previously required to perform all internal machining on J47 jet engine aft frames, which are a basic structural member of the engine. The two-station, three-head unit, designed by Solar and built by Ex-Cell-O Corp. in Detroit, replaces three large vertical turret lathes. It also does a better job: aft frames must be machined to critical tolerances, and they consist of many diameters, all of which must be closely concentric. So there are obvious advantages in the single chucking of the new Ex-Cell-O unit against the three chuckings required in the past.

In operation, the new machine—the only one of its type in the world— automatically moves the aft frames (which are large alloy steel weldments weigh-





3. This 19-ton, $90,000 boring and facing unit chops 87% off the time previously required to do all internal machining on J47 jet engine aft frames. The machine is at work on an aft frame; the operator needs only to push a button to send the unit through its complex cycle. Figure 4, at left, shows close-up of the unit.

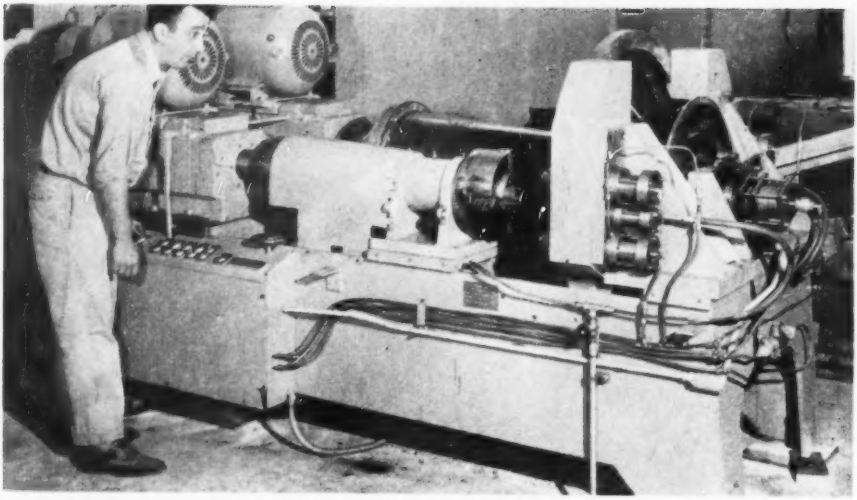
ing 185 pounds and almost four feet long) from the first to the second station, while the three machining heads work in precise cycles to bore, counterbore, face and chamfer various surfaces. Complete floor-to-floor cycle time is only 30 minutes, about 13 percent of the previous time requirement. And another advantage is that the new machine occupies 70 percent less space

5. The aft frame production line is based on a roller conveyor system. Compared with past methods the present system saves about 13 hours of work on each unit. Along the line are special purpose high production machines as well as other welding, machining and assembly operations.

than would be needed for enough boring mills to do the same job.

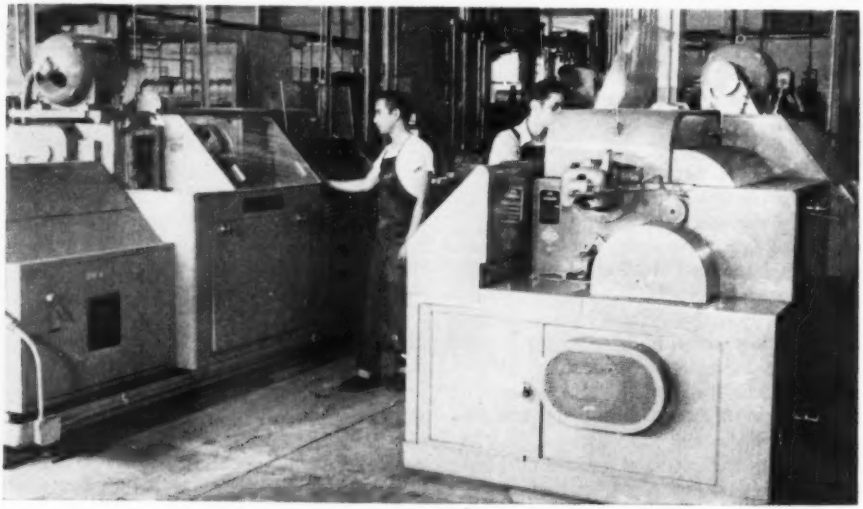
Another special purpose unit is an eyelet finishing machine, designed by Solar, figure 6. It consists of two purchased Ex-Cell-O power units, assembled into the final unit by Arrowsmith of Los Angeles. This machine finish-bores and faces the eight eyelets of the aft frame in four indexes, two at a time. It has one machining head on each side of the machine. These heads, working simultaneously, automatically finish bore, face, turn the diameter, chamfer, and undercut the back of the flange on the aft frame. Total time required is 75 minutes; previously, the work was done on radial drill presses with pot fixtures underneath, which had to be indexed around the eyelets and each eyelet had to be dialed in with a dial indicator, requiring total time of 150 minutes.

In several cases, Solar-designed special purpose tools have cost less than would standard machine tools to do the same jobs, in addition to boosting productivity. One case is a machine designed to drill 80 holes of 9/32 inch diameter in the outer flange of a jet engine exhaust cone assembly. It consists of four Kingsbury heads mounted vertically at 90 degree intervals, drilling four holes during each of 20 cycles, with indexing done by hand. A roller-mounted indexing ring is located on a central vertical column The cone is located for drilling by five clamps, pro-



6. This eyelet finishing machine is a special purpose, high production unit consisting of two Ex-Cell-O power units built into a single assembly by Arrowsmith Tool and Die. It bores two eyelets at one time on a jet engine aft frame in a horizontal position. Eight eyelets can be machined in four indexes.

7. Three Cleveland automatic chucking machines produce flanges and detailed parts. They are controlled electrically with automatic feed and are automatically regulated for each index of the turret. One man operates several machines.



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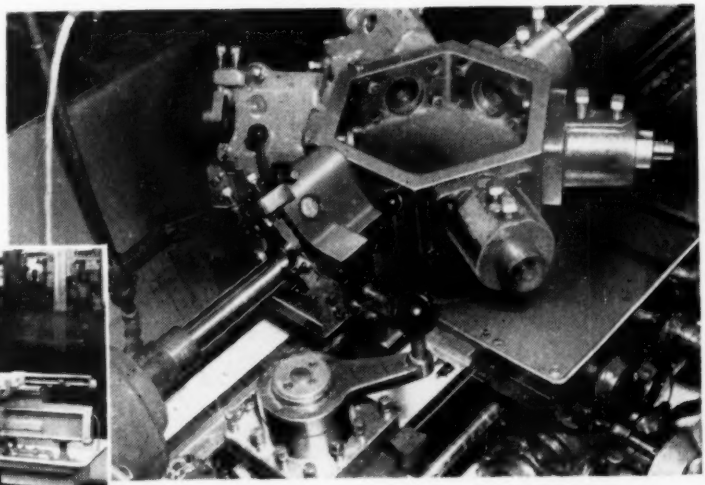

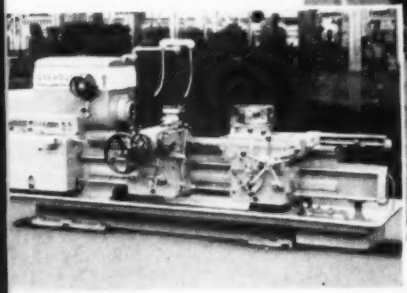

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8. This Lodge and Shipley T-lathe is a new machine tool especially developed for machining large diameter jet engine parts. It has a 60-inch swing and does the job cheaper, more efficiently and requires less floor space than the machine previously used.

vided with bushings to locate the holes for drilling. Compressed air is used with the coolant to force it against the metal being drilled. The entire unit is enclosed in a housing with access doors for changing drills and removing heads when necessary. The machine was designed by us and built by Service Metals of Los Angeles. It eliminated the need for a multiple drill that would have cost $15,000 and required a year for delivery. It saved on floor space, and since it is loaded directly by an overhead crane, no complicated positioning is necessary.

These examples could be continued to cover many other special purpose units designed to speed jet parts output. But standard high production machines are also being utilized. Multiple spindle drilling, for example, is in extensive use at the plant—both Natco and Baush units, running up to 40 spindles. One 36-spindle Natco is used to drill 72 holes, of three different diameters, in an aft frame. Including one index, the operating time is 18 minutes, against 2 hours formerly required using a radial drill

9. A nibbler: a machine tool used to trim the edges of complicated steel shapes is one of the special tools designed and built by Solar Aircraft Company. The company has announced that it is building some of these special tools to fill orders from leading British metal working firms.

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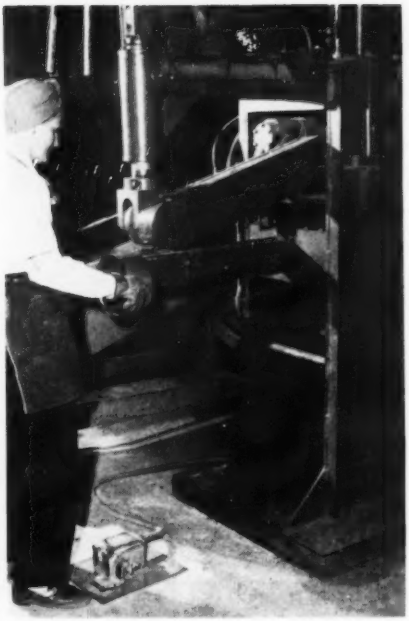

10. This seam leveling machine was developed to improve the tensile and elongation properties of welded parts. On Type 321 stainless steel, tensile strength is increased 14% while elongation is increased 11%. While percentages differ, similar results are obtained on metals ranging from mild and low alloy steels to high nickel content alloys. The seam leveling machine works by passing the weld between hardened steel pressure rolls while pressures up to 55,000 psi are being exerted.

press. Some other examples of time saving with multiple spindle drills include these:

A 40-spindle Baush is used to drill 80 holes in the large flange of an exhaust cone; another is used to do the same

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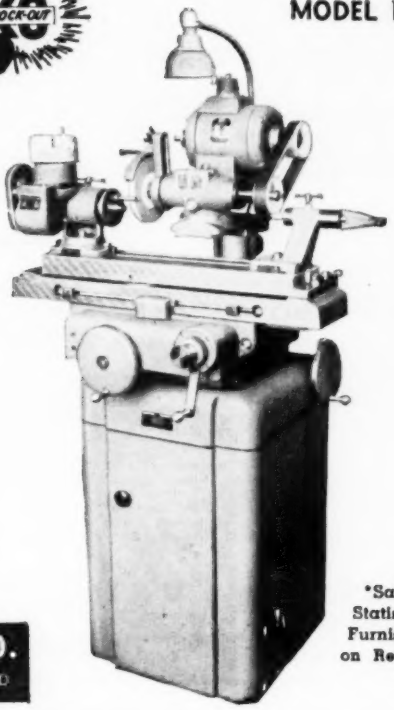
MODEL B860



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thing on an aft frame. In both cases time has been cut to 20 minutes from one hour.

A 24-spindle Natco is used to drill 24 holes in the flange of a small exhaust cone. It does the work in 15 minutes instead of 52.

Along with multiple spindle drilling, we are making extensive use of automatic chucking machines and new types of lathes, figure 7. The automatic chucking machines are used, for example, to produce small flanges. Formerly, these were made on hand-operated turret lathes, requiring a skilled operator. Now, using the automatic chucking machines, unskilled operators turn out better quality products in greater quantities. One part formerly required 50 minutes operating time on a turret lathe; the chucking machine turns out the same part in 14 minutes.

In another case, Lodge & Shipley T-

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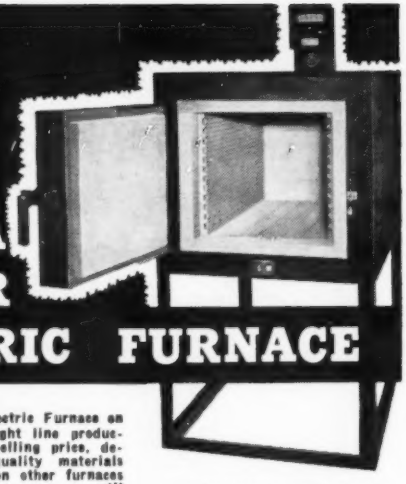

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lathes are used to replace vertical boring mills, figure 8. A 36-inch diameter flange required 283 minutes to machine on a vertical turret lathe; now it is machined on the T-lathe in 161 minutes, saving more than two hours on each part.

By designing much of its own welding equipment and by modifying standard welding techniques, Solar has been able to boost output substantially on many of the jet parts operations. Here are two examples:

We designed a welding unit known as an inert arc circumferential welder. It is used to make a weld of 92 inch circumference. The fabrication was originally manually welded, with each weld requiring 45 minutes. This automatic machine cut the time of each weld to 6-2/3 minutes. Complete cycle time (loading, fitting, welding and unload-

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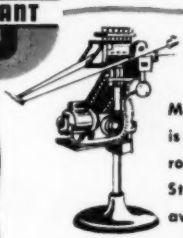

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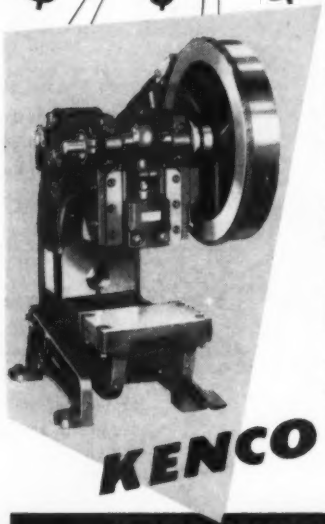
ing) was reduced from one hour to 23 minutes per part.

In another case we modified a roll welder to make a seamweld, three inches in diameter, around the reinforcing patches on the fuel manifolds of jet engine exhaust cones. Previously the work was done by single spotwelds, and required about four hours for each cone. The new machine requires only 45 minutes per cone. To do this particular work, we had estimated that seven spot welders would be needed, costing altogether $49,000. The new unit was built to our design, does all the work originally planned for the seven machines, and cost only $14,000.

These special purpose and standard high production machines—along with a variety of Solar-designed welding units and other special equipment—have been integrated into production

THE PRESS THAT PUNCHES OUT PROFITS



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lines to mass produce major jet engine "hot parts," figures 9 and 10. On inner and outer combustion chambers and transition liners, conveyorized lines help minimize handling and moving costs, decrease storage problems, and reduce the quantity of parts and material in process. On all these lines operations include forming and piercing on presses assigned to specific tasks, arc welding, spot welding, roll welding, pressure testing, and various allied jobs such as deburring and clean-up. Each conveyor line is moving at a predetermined rate with work stations spaced according to operation time required. On inner combustion chambers, one completed unit can be turned out every 2-1/2 minutes. On transition liners, the rate is one every 3-1/2 minutes, and on outer combustion chambers, one every 5 minutes.

Although they are not mechanized, but are based on roller conveyors, both aft frames and exhaust cones are also set up on production lines. Operations along these lines include assembly, heli-arc and metallic arc welding, spot welding, roll welding, machining, drilling, tapping and de-burring. Along this line are some of the special purpose machines described earlier. Final inspection and boxing for shipment are the last two stations in both lines.

All of the shift from former methods to the present mass production techniques on jet parts at Solar-San Diego naturally involved a great deal of rearrangement. Altogether, about 1500 pieces of equipment and machinery were moved and installed over a nine-month period. Three buildings were involved. All moves had to be made with two major considerations in mind: sequence of operations, so that a space would be cleared before a new machine was moved in; and production schedules, so that work would be interrupted as little as possible. The entire project was carried out by using the layout control methods of mass production industries.

The End

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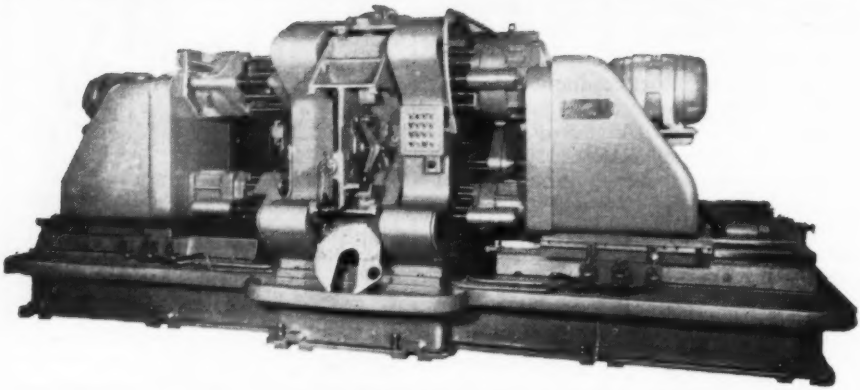

Illustrated is one of the special machines we are constantly building, in addition to our line of MULTIPLE DRILL HEADS, to meet the specific requirements of plants, large and small. This machine is used for drilling, boring and tapping the adapter plate on an automatic transmission . . . The part is completely bored, drilled and tapped on this machine. We are using two of our Standard HH-20 Horizontal Way Type Units with an Automatic Index . . . The complete cycle is 30 seconds. The part is clamped with hydraulic cylinders.

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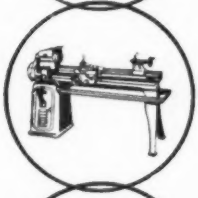

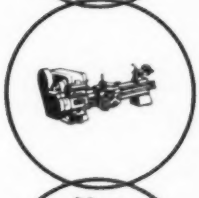

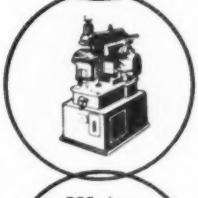

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9

Special Machines Produce Components Of Jet Engines

By **M. Bryan Baker,**
Associate Editor

ACQAINTING MANUFACTURERS with a few representative types of the many machines and instruments especially developed for the vast jet engine program is the main purpose of the following sections.

Obviously, we can but scratch the surface of such a tremendous project that must necessarily demand a never-ending change of requirements, thus making a strictly up-to-date list virtually impossible.

Many of the developments are too top secret to appear and lack of space alone prohibits covering more than a few, but the ones chosen are typical examples of what is being done along this line throughout America.

These sections include: (1) rotor, compressor, turbine wheels, rings, discs; (2) buckets and blades; (3) testing equipment; (4) miscellaneous, such as chucks, cone and housing manufacture, cutting tools, etc.

Before getting into the actual material covering the special developments, it might be well to briefly explain the basic difference in the terms "blades," "buckets" and "vanes," since they are referred to repeatedly throughout most of the sections, and are ofttimes confused.

Buckets are caused to rotate by hot gases, such as a turbine bucket that is turned by pressure of gas against the buckets. The blades rotate and are used to compress gas. A rotor blade is an example. Vanes are stationary. They are used to change direction of gases, such as a stator vane in a nozzle diaphragm vane or a compressor.

...a

Rotor, Compressor, Turbine Wheels, Discs, Demand Close Tolerances . . . Ruggedness

A SHAFT, DISC OR WHEEL and the buckets are the three main parts of a turbine wheel assembly; but, because various rings play such a vital part and are so closely allied with such an assembly, they will be covered in this section. Also, their machining presents many of the same problems as the discs and other large diameter pieces.

The turbine wheel with its components is one of the assemblies of a jet engine that really has to "take it." Buckets (covered under separate section) of the wheel are subjected to a fluctuating stream of hot gases which raises their temperature high and causes vibration and centrifugal stresses. This, in turn, causes the entire wheel assembly to be subjected to heat by conduction from the other parts which comprise the assembly. The wheel may also, in many cases, be heated directly by the combustion gases. Besides this, thermal stresses are set up because of the high temperature gradient that exists between the center of the disc and the rim.

In the centrifugal-flow engine, the front end of the shaft is splined to fit a coupling that connects the impeller shaft and the turbine shaft, but in the axial flow jet the front end of the shaft is splined to fit into the compressor rotor hub. In fastening the turbine wheel and shaft the latter is sometimes fastened to a short

Large numbers of rings in variety of materials, sizes needed: short, large diameter, thin-wall section work poses many machining problems.

Note: Although all leading machine tool builders are represented in most of the jet engine manufacturing plants today, standard tools have been avoided in the following discussions in favor of the developments in special machinery alone. The reasons for this are obvious. Lack of space would prohibit proper coverage of all standard machines and although we cannot presume to include the entire field of special machines, it is hoped that a manufacturer having problems in any phase of jet manufacture, or contemplating entering the field, might find leads as to what is being done by specially developed machines.

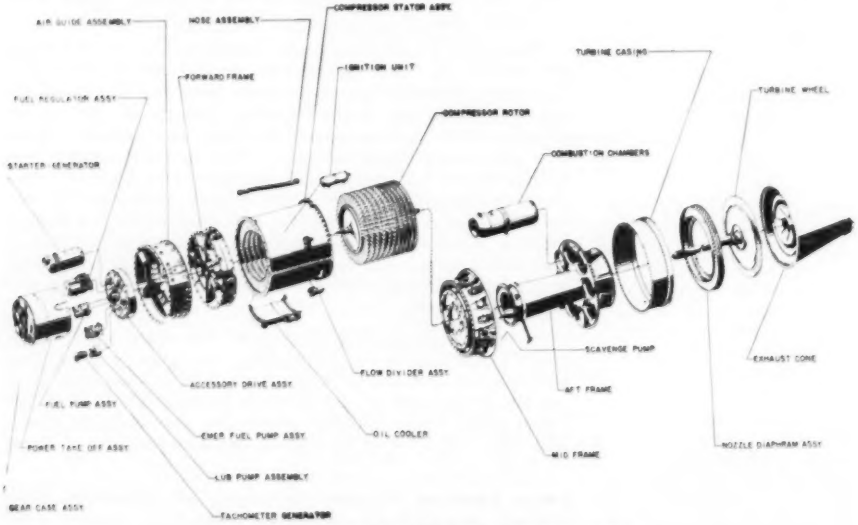
butt, which sticks out from the center of the turbine wheel, by welding the two together. Some turbine discs are in the shape of a doughnut and are electric-welded to the shaft, in as many as 26 passes.

Wheel blanks are usually of Timken steel.

Although the jet engine is supposedly simpler to build than the piston aircraft engine, there are countless troublesome grinding and machining operations caused by the super stainless steels that work harden so easily, the high-heat-resistant alloys and the surface finishes required, not to mention the extremely close tolerances that are necessary.

Compressor Wheels, Casings, Stator Rings Each Produces Its Own Machining Problem

In axial-flow jets, compressor rotor blades are attached to disc rims with trapezoidally-shaped dovetails, but the compressor casing or stator is horizontally split into halves and bolted together around the rotor and secured at the ends of the cast aluminum alloy forward frame and midframe. The sta-



Parts of a typical axial-flow turbojet engine.

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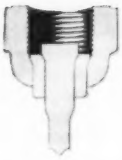

You both speed production and cut costs when you adapt your punching machines to use standard tools. With the Cleveland System of Standardization the *same* coupling nut and punch stem holds a wide range of punch sizes. As shown here, sleeves are used to adapt the smaller punches of any series to the coupling nut. For instance, by the use of but two sleeves, you punch holes ranging from 1/8" to 1 1/16" inclusive without changing nut or punch stem. This greatly reduces tool set-up time without reducing flexibility of operation.

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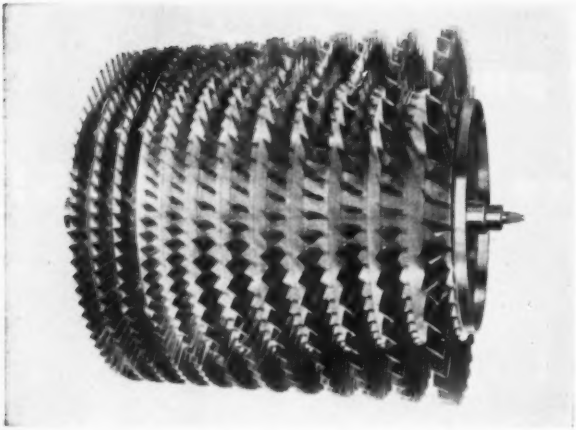
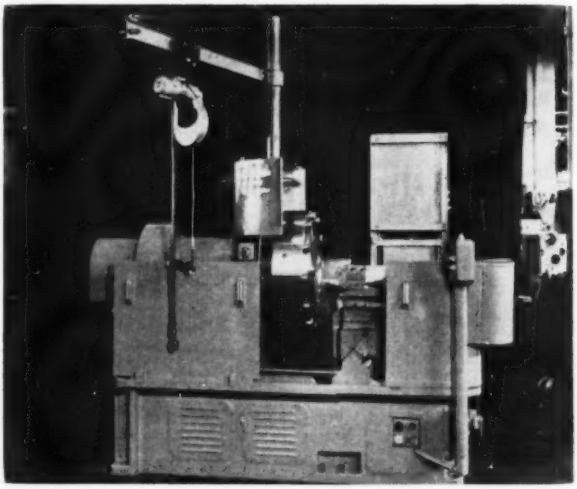


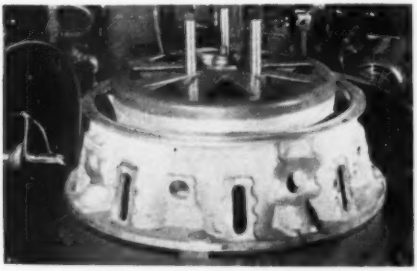
A complete compressor rotor. The usual axial-flow type of compressor is made up of many stages. This one consists of 12 bladed discs shrunk on a steel shaft. This is then enclosed in a cast-aluminum outer casing.

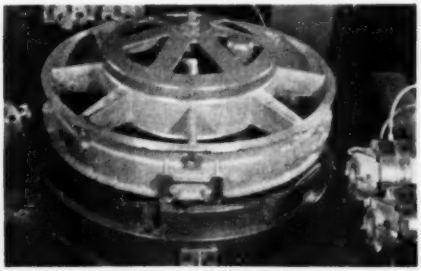
tor blades are dovetailed into split rings, which are in turn assembled into the stator halves. Eleven rows of stationary blades are used, followed by two rows of final straightening vanes. The typical compressor consists of 11 bladed discs shrunk on a steel shaft and enclosed in a cast aluminum outer casing. In an 11-stage compressor, the first 10 discs performing the first 10 stages are machined from aluminum forgings; the 11th disc (last compressor stage) is a heat-treated steel forging directly linked by a splined fit of the turbine shaft. Higher cycle-pressure ratios are constantly being sought; however, several barriers stand in the way, including compressor pulsation and higher temperatures. The former is reduced through close tolerance machining in conjunction with design. New metals may whip the latter. In the meantime newer, faster, more economical methods and machines continue to be developed.

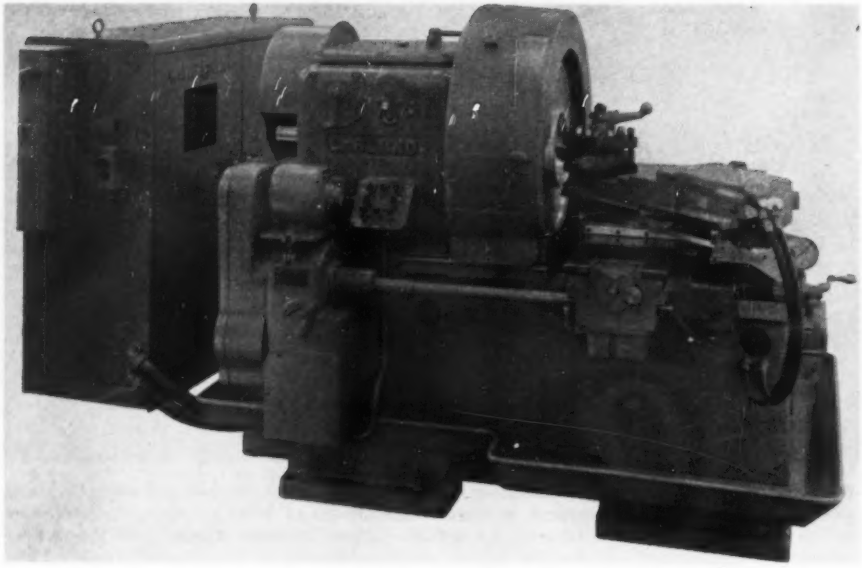


A special precision contour facing machine, the Model 330, for large diameter jet parts, has been developed by New Britain-Gridley Machine Div., New Britain Machine Co.; the workpiece shown is a compressor wheel.

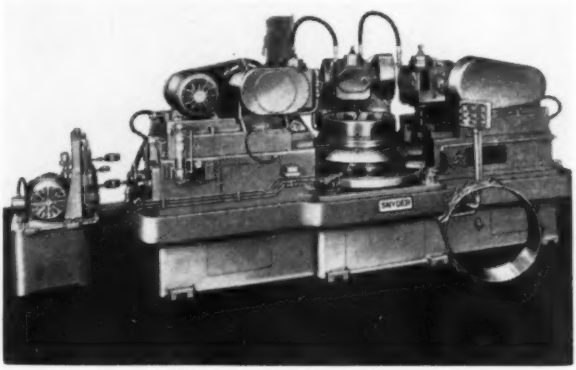
Used for milling compressor frames for jets, these machines made by Ingersoll, all of somewhat similar design, operate at spindle speeds up to 1780 r.p.m., with feed rates of up to 70" per minute. All employ carbide tipped inserted blade cutters and use kerosene as a coolant. **At the top** is the special design four-spindle, three-head index type milling machine that rough and finish mills 12 pads on the periphery of aluminum rear compressor frames, six frames per hour. The machine bed carries an index table 36" in diameter, which is hydraulically indexed to eight positions. Bed wings located around the table contain the heads, all of which feed horizontally, and two of which also travel vertically on knee type ways. Two of the heads, one for rough milling and the other for finishing, have single spindles. The third head has two spindles—one rough mills and the other finish mills. Feed and traverse of the heads are hydraulically controlled. After the operator presses the starting button, the full cycle is under automatic control. **Lower left** is a two-spindle, two-head index type milling machine; it rough and finish mills three pads on the periphery of aluminum rear compressor frames; 7.9 frames per hour. The machine bed carries and index table 36" in diameter which is hydraulically indexed to eight positions. **Lower right** is a six-spindle, three-head index type milling machine showing a magnesium compressor frame in position; it rough and finish mills 16 pads on the periphery; 6.7 frames per hour. Each of the three heads has two spindles, one for rough milling and the other for finishing.







A jet engine aluminum compressor disc being profile faced on a LeBlond No. 1 contour facing machine equipped with reversing cycle. The tool begins its cut on a 16" diameter at 208 r.p.m. which results in 870 s.f.p.m. This surface speed is maintained by variable speed control until a maximum of 550 r.p.m. have been reached at 6" diameter. The spindle speed is then kept constant across the center until the tool is 3" beyond the center and deceleration is begun. At the end of the cut, the tool is cutting on a 23" diameter and the spindle speed has been reduced to 145 r.p.m. When using a feed of .012" the cycle time, exclusive of loading, is 4 minutes 50 seconds.



The automatic machine developed for processing compressor casings. It mills to a depth of 1 3/8" at the extreme; two rough cuts and one finish cut.

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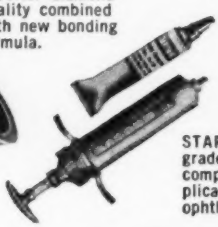

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ACE ABRASIVE LABORATORIES

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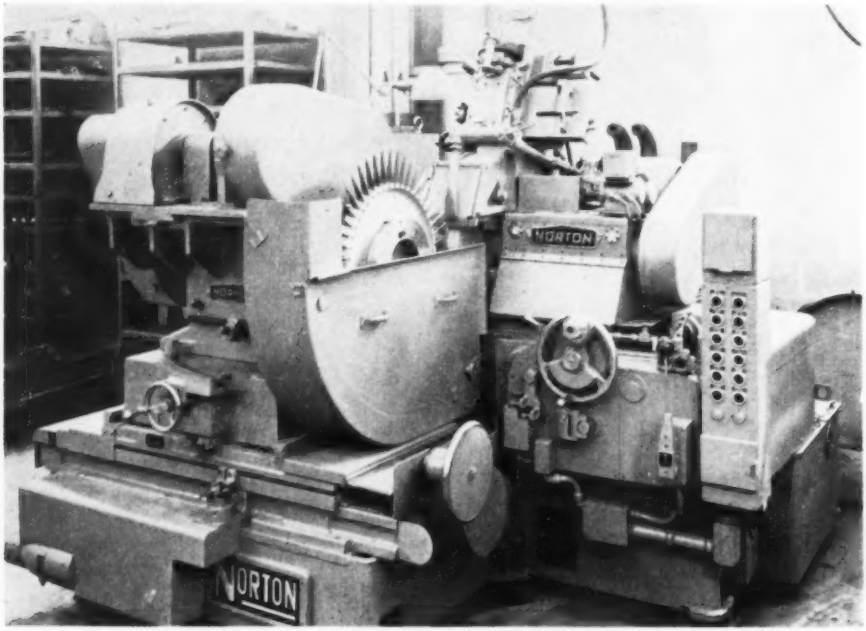
Profiling four rows of lugs projecting from the outside of a compressor casing was a bottleneck for one manufacturer. The workpiece was a thin-walled cylinder made from one of the tougher stainless steels. The lugs projected from the outside like fins. Snyder Tool & Eng. Co. developed an automatic machine for milling to a depth of 1⅜" at the extreme. The milling is done in three steps, two rough cuts and one finish cut.

The machine consists of a fixture mounted on a rotary table driven by a hydraulic fluid motor. Spaced around the table are three-way type milling units, each controlled by a Turchan follower hydraulic system. One of the units does the profiling of all four rows of lugs and the other two units cut off some of the lugs at different intervals to complete the finished part. The fixture locates the part from an o.d. at one end and clamps and thoroughly supports the part by means of four expanding jaws on the i.d. of the part.

Four toe clamps hold the part down in the pilot ring.

Loading and clamping takes about six minutes, each of the three cuts 37 minutes, each of the three tool settings four minutes, unclamping and unloading about six minutes, giving a total time around 135 minutes.



This is the 42" compressor wheel grinder developed by Norton; the workhead spindle is designed for convenient mounting of face plates, chucks, or other workholding fixtures. The workhead is mounted on a swivel table and has longitudinal and cross adjustments. The workhead table also has longitudinal power traverse with automatic reversals from a hydraulic motor unit.

A 42" compressor wheel grinding machine, with features that simplify grinding operations on jet aircraft components such as turbine and compressor discs and wheels, shroud and spacer assemblies or blade holding fixtures, is a development of Norton. A particular feature is the convenience of mounting these parts on the workhead face plate or particular work holding equipment that is best suited to the job. Rotary magnetic chucks and hydraulically or air operated fixtures are among the types which may be supplied. Work spindle center height is only 3½ ft. from the floor, facilitating loading and unloading the large diameter parts.

The automatic grinding cycle operates under one-lever control. This includes rapid advance of the grinding wheel, a cushioning, a grinding feed adjustable both as to length and rate, rapid withdrawal of the grinding wheel on completion of the grind, and automatic control of work rotation and cool-

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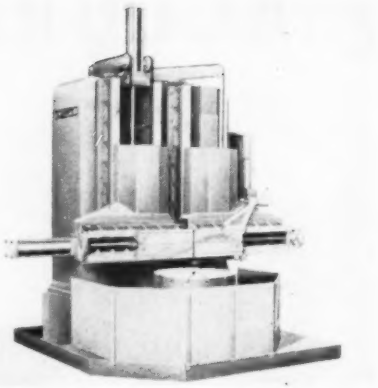
ant flow. Special arrangements such as automatic wheel wear compensation, automatic multi-step grinding, and special equipment for spindle reciprocation and shoulder grinding can also be furnished. An automatic wheel guard type truing device operates under push button control and trues the wheel, minimizing disturbance of settings.

For compressor wheel contour semi-finishing and finishing, Ex-Cell-O has developed a new vertical spindle production machine, the 426-A, with two-dimensional electronic tracer control, a tracer controlled tool slide to generate accurate forms, and a second tool slide performing such operations as grooving or turning and feed-facing. It is a massive, rigid machine with heavy duty, high speed work spindle and flexible automatic cycles, and is being used in conjunction with Ex-Cell-O's Style 425 vertical precision boring machine for operations on compressor wheels. Automatic functions of the 426-A include the control of all slide movements during the cycle, control of speeds and



This Style 426-A vertical precision contouring machine, developed by Ex-Cell-O for machining of large round parts such as jet engine compressor wheels, has one electronically controlled compound slide for contouring operations, another hydraulically operated compound slide for turning, facing, grooving and rabbeting.

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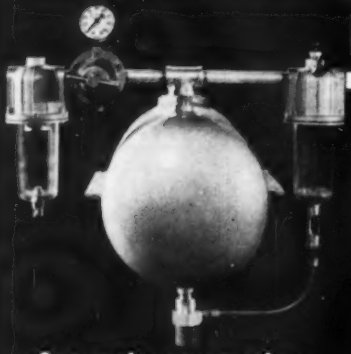

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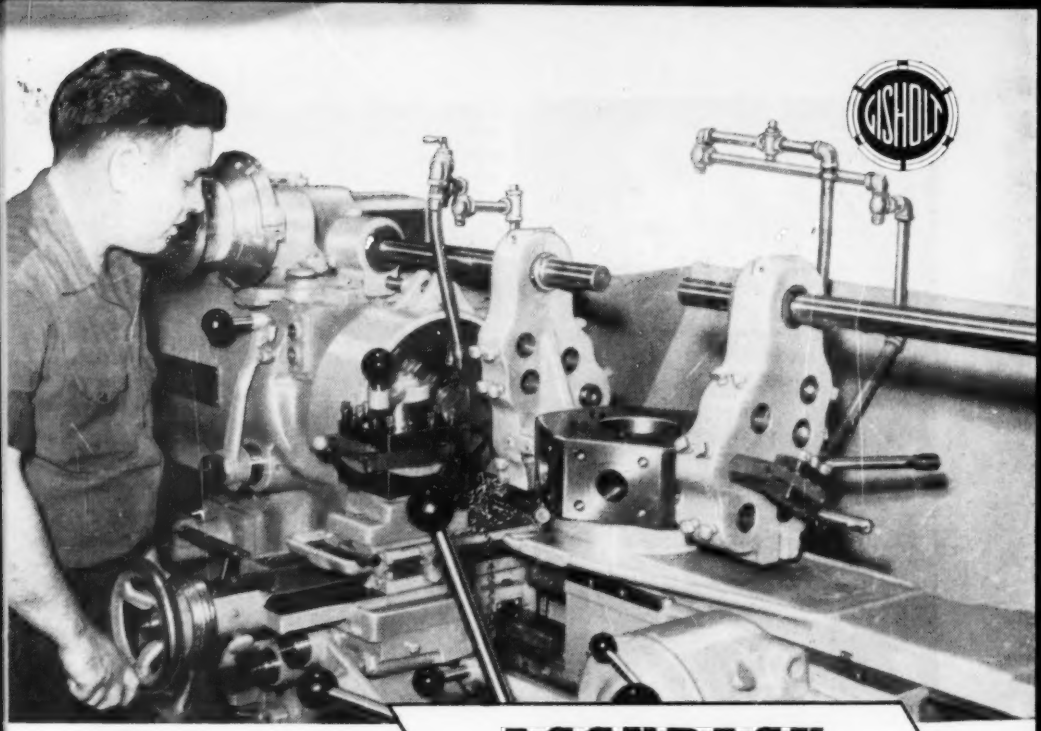

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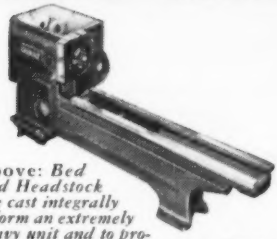
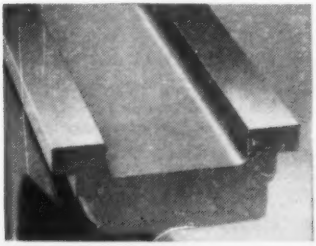


Above: *Bed and Headstock are cast integrally to form an extremely heavy unit and to provide the rigid foundation for all types of work.*

Below: *Block type ways are straddle keyed to the bed and ground in perfect alignment with the spindle. All working surfaces are hardened to 64-66 Rockwell "C".*



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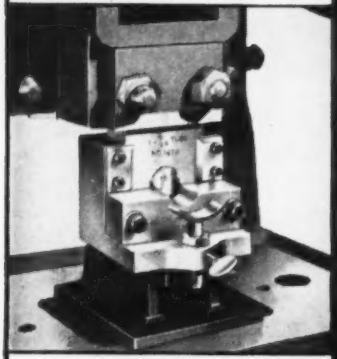

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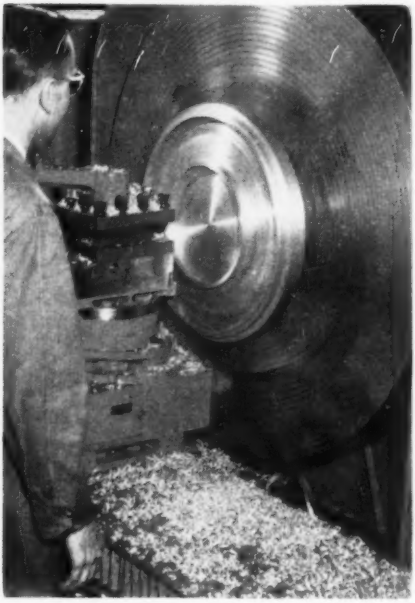
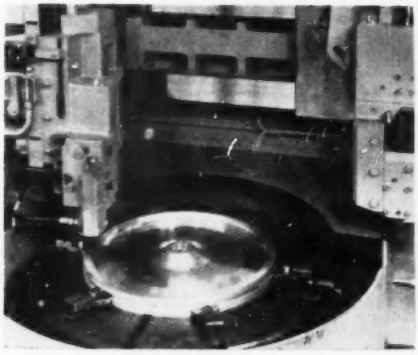
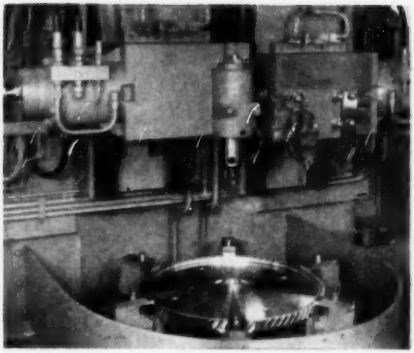
feeds during contouring, change to a selected work spindle speed for operation of the left hand compound slide, and coolant flow control.



Often disc-shaped components have to be machined in various combinations of straight sections and continuously varying contours. In the case of the Monarch Model 0, 60" right angle lathe, two slides are employed, one for turning and one for boring, with one or both Air-Gage tracer controlled. While this machine is intended particularly for turning and boring and their Model F for facing, either can be used for all three operations. However, the Model F is provided with constant surface cutting speed. Therefore, facing operations over a considerable diameter range can be performed only on the latter. Illustrated is the Model F facing a jet engine compressor disc. Only one slide is used. Automatic spindle speed control functions on both sides of spindle center. When it is necessary for the tool to cut on both sides of center in order to complete the face (as above), the reversing control of the work drive motor operates automatically as the tool approaches center.





Left, a compressor wheel on the 426-A contouring machine. Here the web from the central hub to the outer rim is turned by a tool in the tracer-controlled contouring slide. Tools on the left side finish surfaces on the rim. **On the right is shown** a jet compressor wheel on the Style 425 Ex-Cell-O precision boring machine. The left-hand compound slide precision bores the central hole and faces the hub. The right-hand compound slide finishes a rabbet in the outer rim. The machine is tooled up for precision boring, counterboring and chamfering the central hole and facing the small hub. The part is an aluminum rotor disc.

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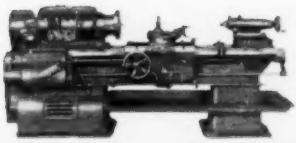
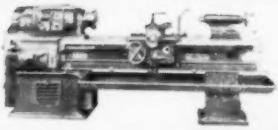
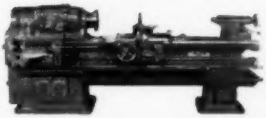


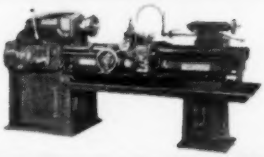
18" — 20" — 24" 12-speed Geared Head Lathes



12" — 14" — 16" 18-speed Geared Head Lathes



12" — 14" — 16" 12-speed Geared Head Lathes



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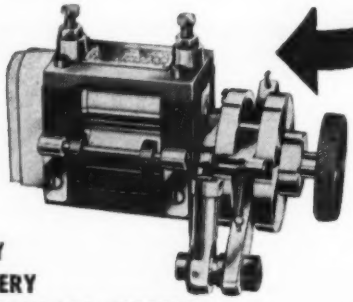

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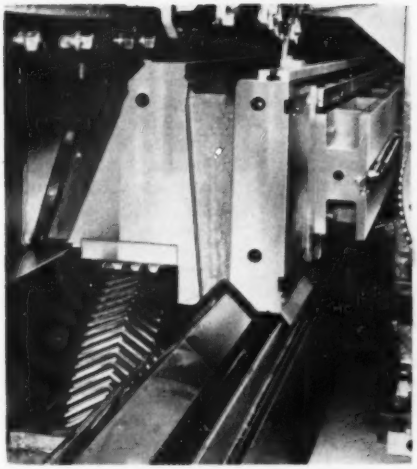
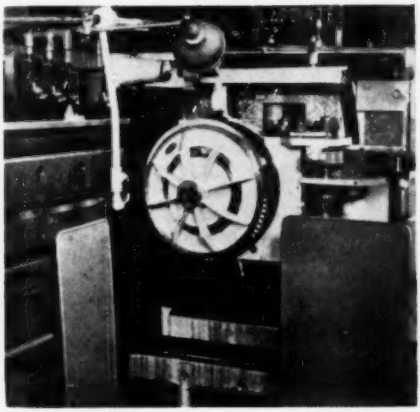
circular components. Many contours not ordinarily capable of being developed can be duplicated rapidly through this vertical slide movement.

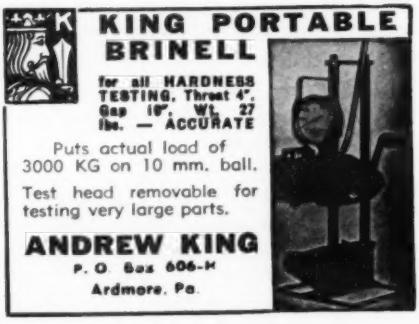
A broaching development that is receiving wide acceptance among jet manufacturers is the new LaPointe electric drive broaching machine that is capable of doing over 300 f.p.m., resulting in better finish and increased production. At these speeds carbide tooth broaches can also be used.

Optional equipment on this machine includes dual speed and dual cycle. The dual speed feature permits the machine to be operated at two or more predetermined speeds for the same broaching stroke. This choice of speed allows the maximum opportunity to obtain the best possible finish in one stroke, for frequently improved surface finish can be obtained at different speeds. Dual cycle is also available, allowing broaching the jet components without requir-





On the left is the new LaPointe electric drive broaching machine capable of over 300 f.p.m. Limit switches for dual speed and dual cycle operation provide versatility. The machine has a massive main slide driven by a continuous tooth herringbone bull gear and rack, shown at the right. The main slide rides on phenolic ways, is adjustable and is guided and supported throughout the entire stroke.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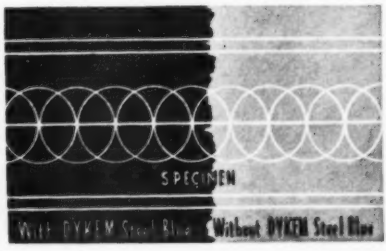
ing tool changeovers for the accuracy required. For example, in broaching turbine discs all slots can be roughed out at one speed, and then finished at a higher speed to prevent distortion, and get greater accuracy.

Four different strokes are available on these machines from 100" to 180". Two slide widths are offered, 16" and 24". Electric drives up to 200 h.p. can be had, depending on speed desired and amount of material to be removed.



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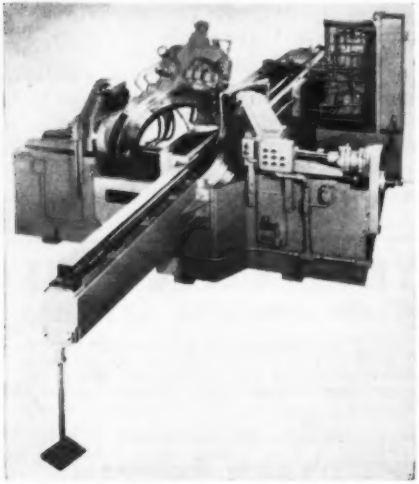
External, Internal Broaching of Rings

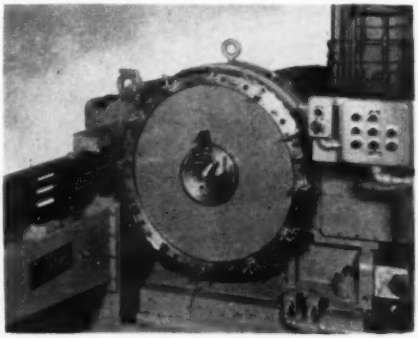
In one type of jet engine the front compressor rotor discs are of aluminum alloy, last three steel. These carry blades in dovetail slots in their rims. Turbine discs are generally of steel, forged integral with the turbine shaft, but carrying a shrunk and welded rim of Timken alloy into which pinetree root buckets are inserted. Compressor rotor and stator blades are pressed tightly into slots, stator vanes into dovetails in the stator ring, which in turn slips into a T-groove in the body or housing. Slots of pinetree and dovetail shapes are broached in a single pass per slot, in the Timken alloy. Blade roots are broached also in a single pass.

Horizontal broaching machines for automatic broaching of external scallops or slots on different types of jet engine rings have been developed by the Colonial Broach Co.; one broaches three scallops with each pass of the ram and another a single dovetail slot with each stroke.

With a trunnion-fixture-equipped broaching machine the indexing, diameter of the work, and the angle of the cut can all be adapted to the requirements of the work piece, incorporating a fixture which allows angular adjust-

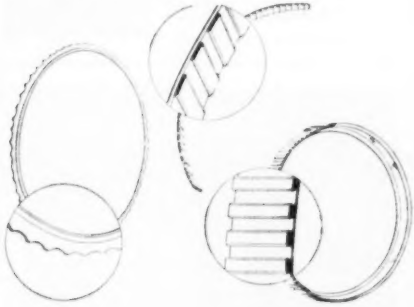


Colonial horizontal broaching machine equipped with special trunnion fixture for internal broaching of slots in jet engine ring segments.



This 10-ton, 60-inch horizontal stroke automatically broaches three external scallops in jet engine rings with each pass of the ram. Indexing, shuttling and broaching are all automatic. Another similar 10-ton, 90-inch stroke machine, not shown, broaches external slots in rings.

Drawings indica'e the types of jet engine parts being produced automatically on these broaching machines.



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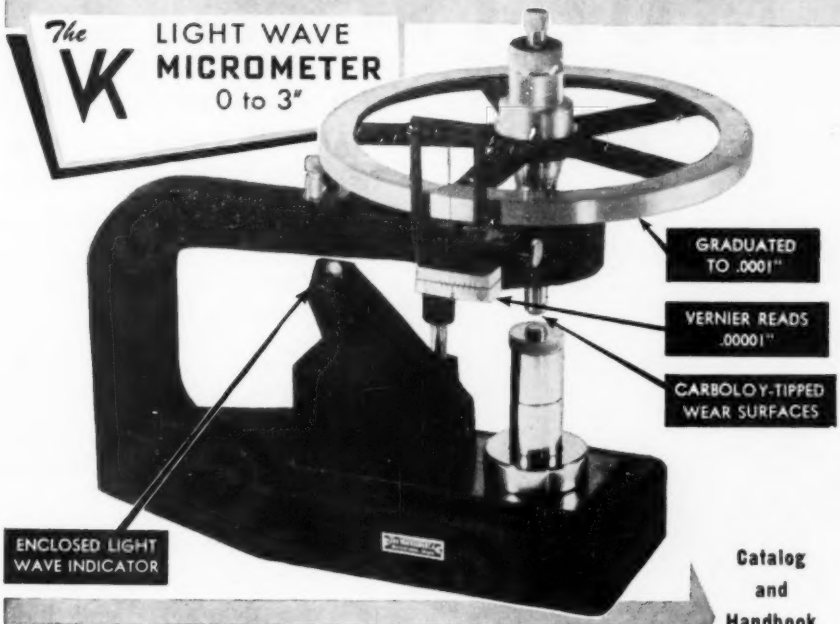

Catalog and Handbook No. 35

The Van Keuren Light Wave Micrometer is an instrument of exceptional accuracy, ideal for measuring plug gages or small precision parts. Use it when you're after "that last hundred thousandth" involved in so many of today's measurements. The 0 to 3" instrument shown above has a ½" diameter, 40 threads per inch micrometer screw, which can be made with greater accuracy, and which has 3 times the wearing surface of an ordinary micrometer screw. It has an 8" diameter micrometer wheel, with .0001" graduations 1/10" apart. It has a non-parallax vernier index which enables readings to be made to .00001". It has an index lock and carboloy-tipped anvil and spindle. This sturdy, sensitive instrument weighs only 17 pounds, and is in reality a portable measuring machine of inbuilt and sustained accuracy.

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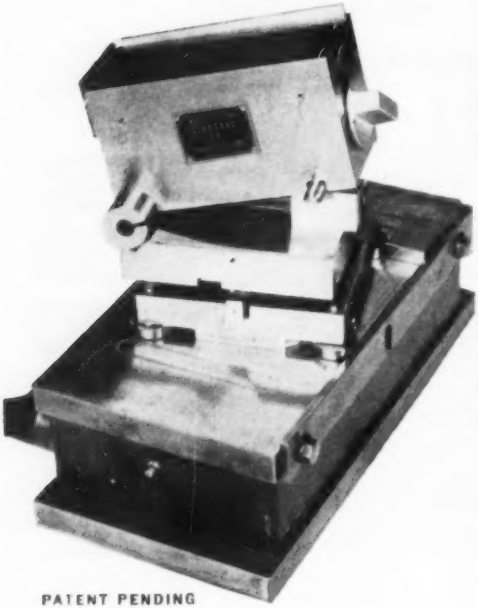

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ment of 15° to 45° for broaching a wide range of internal angular slots in jet engine segments of various diameters.

In another application, heat and corrosion resistant steel 22¾" i.d. jet engine blade supports are broached on internal contours on two 10-ton, 90-in. stroke standard machines at three per hour; 18 passes are required per machine. Metal approximately ¾" deep, 3½" wide, and ½" thick is broached in two passes.

From the standpoint of machining, one of the greatest problems of the jet engine program is the large number of rings of various applications, shapes, sizes and materials that are needed, necessitating a big demand for ring turning equipment. Also, because the jet engine has to be in perfect static and dynamic balance, the close tolerances in the rings and discs pose another very definite machining problem. For in-

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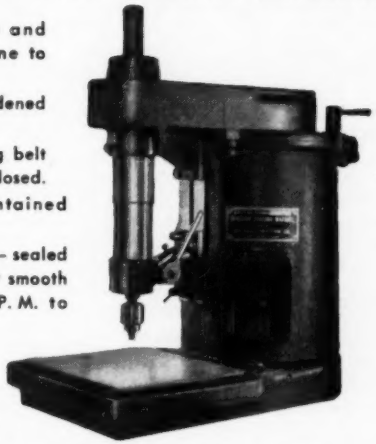

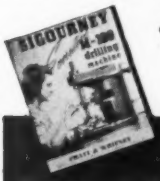

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stance, a finish-machined compressor disc has a cross section of less than 0.100" in places. Another consideration is the ever increasing diameter of the parts. This, of course, is in keeping with the continuing search for increased thrust with the minimum in engine weight.

An important approach to these problems of profile facing cuts has been the development of the T-lathes, such as those manufactured by LeBlond, Lodge & Shipley and Monarch. In ring or disc machining the heavy duty lathes are not needed, but the large swing is required, as are lathes with variable speed motors. In the conventional lathe, the operating angle of the top slide, together with tool limitations, often makes it impossible to complete the required profile from periphery to center in one pass. Thus the across center technique has been developed, whereby outside shoulders are machined when feeding from front to center and inside shoulders are machined when feeding from center to rear. To maintain the same

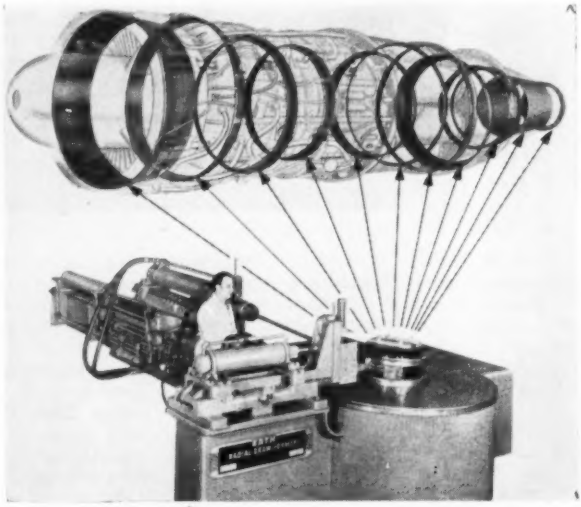
direction of the cross slide, the feed drive as well as the spindle must be reversed when the tool reaches the center. All of these operations, in addition to tool retraction and rapid traverse, are accomplished on machines such as the LeBlond No. 1 contour facing lathe. Lathes of this type are employed mainly for finish profile facing in high production setups. Where discs and wheels for jet engines do not require the across center technique, the non-reversing machine will be economical. This version, while also automatic, needs no spindle and feed reverse. Rings that do not require contouring can be manufactured on a machine that has a power angular feed compound rest instead of the LeBlond Hydra-Trace, in which case manual controls are furnished in place of the automatic cycle.

Ring Forming by Compression, Stretch, Radial Draw Forming

The principle of producing contours by rotary forming (rotating a forming die against material held under tension, or by forcing the material against a rotating die) is not a new one and a number of firms have built machines of this type for their own use. Fields of application of this type machine are mainly that of forming, repeatedly and accurately, shapes that cannot readily be produced by other methods, or are so large and required in quantities that prohibit such methods. The full potentialities of these machines have not been approached. Complex contours in extruded, rolled or brake-formed sections as well as the shaping of sheet-metal panels are common. Most materials can be formed on the machine without a second operation in the hard condition, but in some of the higher strength alloys, such as 75S, two stretching operations may be necessary, first with the material soft and the second after ageing heat treatment.

A radial draw former developed by Cyril Bath Co. is capable of taking a partially preformed strip, plate or sheet and wrapping it around a die to form many types of rings. Shapes can be drawn to a full circle, cut and welded, for required tolerance without further stretching.

Similar to their contour former, it has in addition a side head for applying pressure by shoe or rolls to the work.



This shows the partial range of the new radial draw former. Shallow bends in formed strip stock and sharp bends in flanged extrusions, to full circles and spirals in metals from 24 ST aluminum to titanium of 95% purity, are possible. The machine is used for fuselage parts as well as for making many types of jet engine rings and other components.

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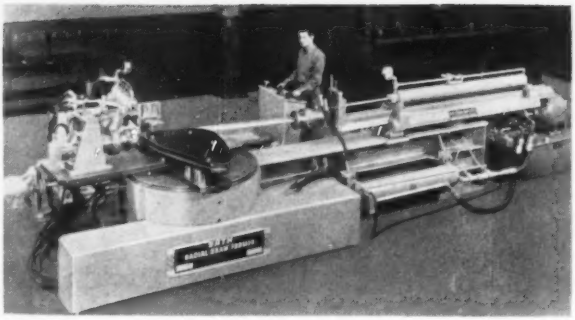

Stretch former manufactured by Cyril Bath has ram cylinder rated at 8 tons stretch capacity with a 72" stroke. The 2½ ton capacity traversing wipe unit has a longitudinal travel of 6 feet, parallel to the bed of the stretch former.

The bed is also longer. Basically the machine consists of a rotary table on which the forming die is mounted and a hydraulically-operated ram which can be moved longitudinally. The frame of the machine is rugged for maximum operational loads. Table diameter ranges from 5 to 10 feet. Shapes possible to form include elliptical, rectangular, or combination shapes, afterburner fronts, mounts, ducts and cones.

The new Bath stretch former consists basically of two related units; namely, the 8 ton stretch former, a substantial and complete unit in its own right, capable of a wide range of work, and the right angle traversing unit that wipe forms the stretched metal on the die.

The stretch former has a ram cylinder rated at 8 tons stretch capacity with a 72" stroke and is mounted on a slide guide radially pivotable on the machine bed. The 48" diameter turntable is capable of 210° rotation and is powered by a hydraulically actuated rack and table spindle gear.

The new 2 ½ ton capacity traversing wipe unit has a longitudinal travel, parallel to the bed of the stretch former, of 6 feet and is actuated by a gear head motor and screw. In addition to the lateral travel, the hydraulically operated traversing right angle ram has a 15° swivel each side of center for increased cross sectional control of the part being contoured.

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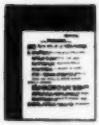

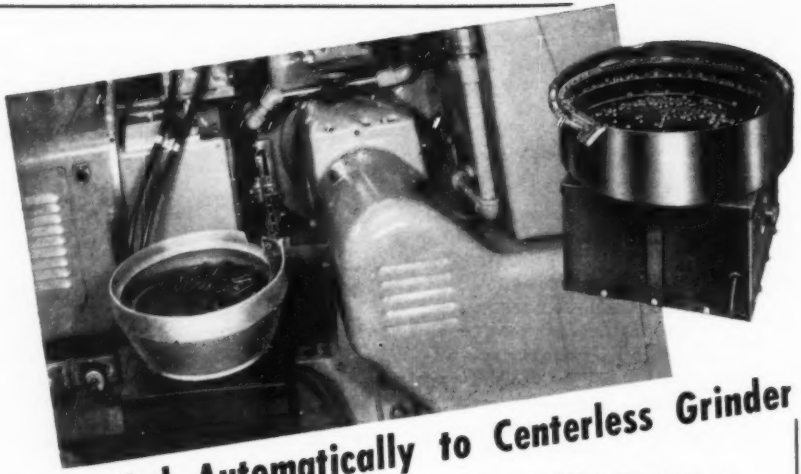

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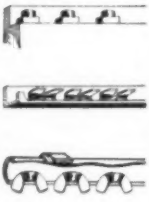

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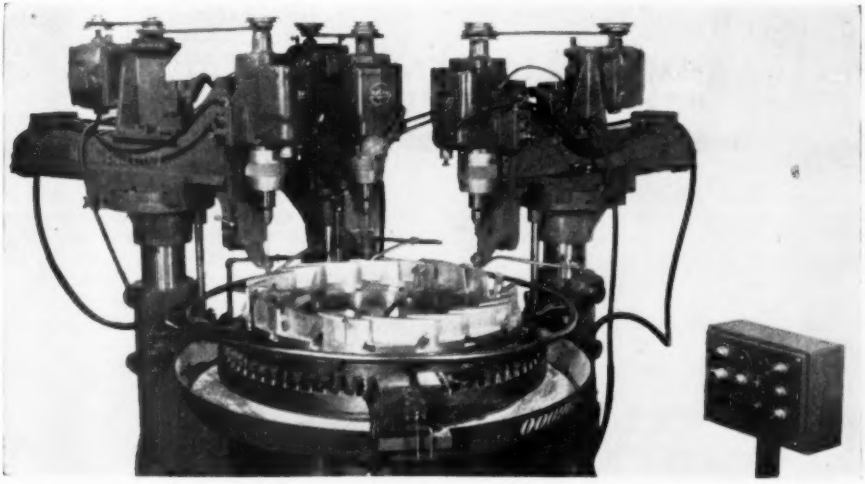

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Such a machine as this is suited for performing operations on the great variety of large circular pieces which constitute a gas turbine engine. It materially cuts down tool expense because large and expensive jigs that are clumsy to use are no longer necessary. When a drill needs sharpening it is quickly changed without disrupting operations

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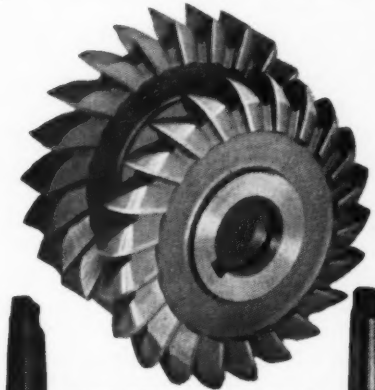

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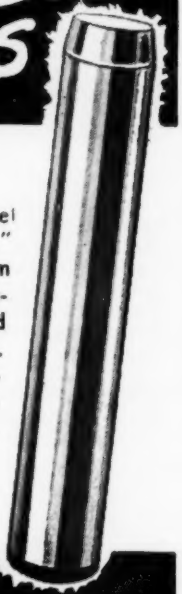

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Shown on this milling machine, that has been converted into an external grinder, is a master index ring for a special broaching machine, one of twenty designed and built by Ace-Central for broaching Christmas-tree blade slots on British jet engine stator rings.

For broaching Christmas-tree slots on British jet engine stator rings, Ace-Central States Machine Tool Co. designed and built 20 special broaching machines. For grinding the master index ring for this special machine, Ace-Central has done a novel conversion job in changing a milling machine into an external grinder, saving as much as two days on work of large diameter. By this method, slots can be ground as accurately as holes on a jig borer. Indexing is done by a simple fixture. Shown on the machine is a master in-

Here is a closeup showing brush heads and wire brush wheels lowered into operating position on the new TT-261 deburring machine, developed for fast deburring of jet engine stator rings, being manufactured by Grinding and Polishing Machinery Corp. Experience indicates a complete time cycle of one minute for loading, deburring and unloading 32" diameter aluminum compressor half rings. Actual deburring time requires about five revolutions of the table or about 24 seconds, with 36 seconds required for loading and unloading.

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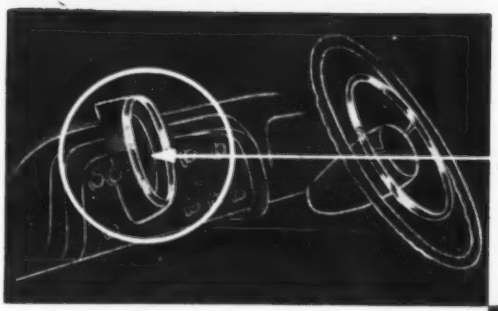

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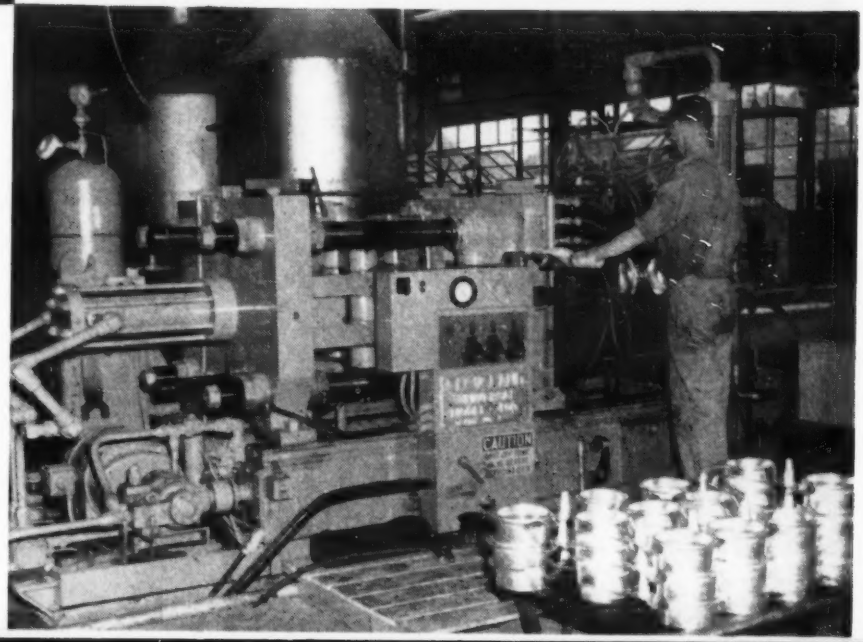
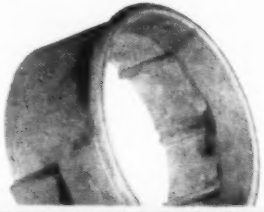


* That's the actual figure, but the abbreviation stands for units *made* per hour — in the Cleveland Die Casting Machine shown at right. Working in the ultra-efficient King-Seeley plant at Scio, Michigan, this Cleveland machine is speeding production of automobile dashboard instrument parts. The part being produced, an instrument cluster housing, is shown below, "as cast."



King-Seeley Corporation, leading supplier of dashboard instruments to major automobile manufacturers, is widely known for excellence of product design and construction; for high efficiency in manufacturing methods. To maintain critical standards in its die casting department, King-Seeley relies on a Model 400 Cleveland to produce top quality castings at high speeds.

King-Seeley uses zinc die castings extensively for such parts as the horn ring shown below; housings for telegages (water temperature, fuel level and oil pressure); bezels; small intricate frames; and speedometer and gauge components. Chances are your car has several King-Seeley products in it.

Typical of the parts produced on this Cleveland machine is the instrument cluster housing shown above. Approximately six pounds of zinc alloy are injected into the die, producing two parts per shot. The Cleveland's powerful die locking pressure and high injection speed produce sound, dense, *"hardware finish"* castings. Dimensions are held to close tolerances. Secondary drilling operations on the part have been eliminated by precision coring of 13 holes. Production averages 213 shots—426 parts —made per hour.

To get the *most* from *your* die casting department—in speed of production and quality of casting—profit from the experience of leading die casters and investigate the advantages of the Model 400 Cleveland. Your inquiries will receive prompt attention. For machine specifications, write for free copy of bulletin.

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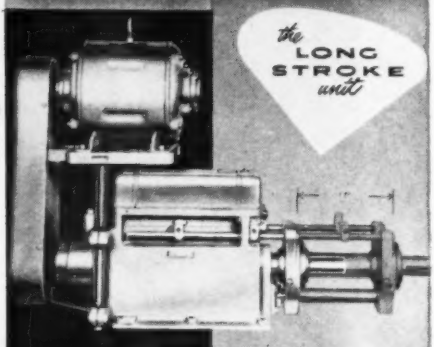

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dex ring for the special broaching machine. The setup handles diameters up to 48".

Deburring that is necessary on many of the components, following the various types of machining operations, has always been a big problem. Previous hand methods of deburring required an eight hour day for a set of 24 compressor stator half rings, for instance.

A special turntable type machine developed by Grinding & Polishing Machinery Corp., Indianapolis, does the job in 12 minutes. The experience of one aircraft company using the machine indicates a complete time cycle of one minute for loading, deburring, and unloading a pair of 32" diameter aluminum half rings. The TT-261 deburring machine was originally developed for fast deburring of jet engine stator rings, half rings or other number of ring sections; a master ring, mounted on and rotated by a large spur gear, serves as a turntable which rotates on a number of closely spaced balls. The construction

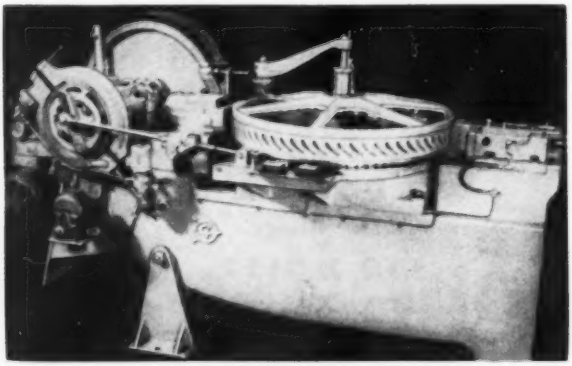
of this assembly is quite similar to a large thrust bearing. This master ring is driven at 12 r.p.m. by a constant speed gear reducing unit from a ½ h.p. motor. An alternate drive is available with a variable speed unit to give 5.5 to 55 r.p.m. of the table.

Interchangeable three jaw holding fixtures for various diameter rings may be provided. These hold ring sections to exact diameters during the deburring operation. Two Vonnegut 32 brush polishing heads, running in opposite directions of rotation, mounted on vertical spindles and driven by 1 h.p. motors, deburr the portions of the broached slots on the flat inside diameters of the rings. The TT-261 is arranged for these units in a fixed vertical position, but an alternative design with a universally adjustable unit mounting can provide for any required degree of tilt for the inside diameters of rings having greater thickness at the top than at the bottom edge. The column supporting the brush head units has

adjustment forward and back on the table top to obtain proper engagement of abrasive for different diameter rings. There are two pairs of small adjustable and reversible air motors, mounted angularly, that drive small wire brush wheels to deburr the slots where they break through the side wall of the channels at the edge of the rings.

A deburring machine that may be converted by a few simple adjustments to a wide range of usefulness is being made by Murray-Way Corp., Birmingham, Mich. The new unit was developed especially for the fast deburring of turbine disc slots and incorporates several positioning features. The head may be used with either wheels or buffs and is exceptionally compact in design, making its use in groupings practical with a minimum of floor area. Two, three or four heads are used as the work requires. Heads may be dropped or added easily if found necessary.

Vane rings hold the vanes (stationary members used to change gas direction, such as a stator vane in a compressor or nozzle diaphragm vane) in slots. In some engines, such as the J47, the



This is the Murray-Way deburring machine for fast, economical deburring of turbine disc slots. The compactness of design makes groupings possible with a minimum of floor area.

This 32-ton capacity horizontal power press, made by V & O Press Co., pierces 64 slots in 40 seconds in a jet engine vane ring for the airfoil blade. The fully automatic piercing operation is accomplished by two slides, adjustable to punch either outside in or inside out.

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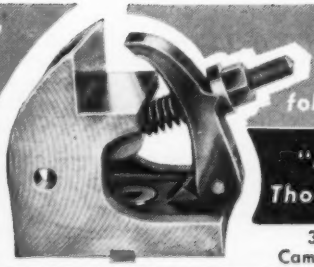

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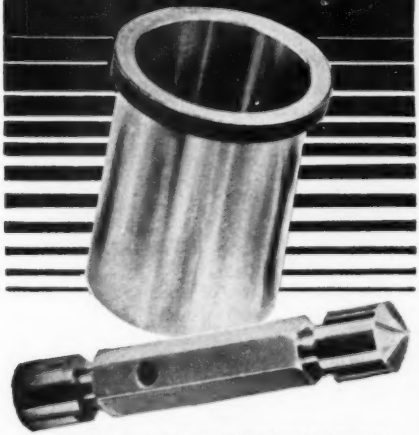

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13/64" x 12"	2.19
7/32" x 12"	2.19
15/64" x 12"	2.40
1/4" x 12"	2.40
17/64" x 12"	2.55
9/32" x 12"	2.55
19/64" x 12"	2.75
5/16" x 12"	2.75
21/64" x 12"	3.11
11/32" x 12"	3.11
23/64" x 12"	3.46
3/8" x 12"	3.46
25/64" x 12"	3.81
13/32" x 12"	3.81
27/64" x 12"	4.17
7/16" x 12"	4.17
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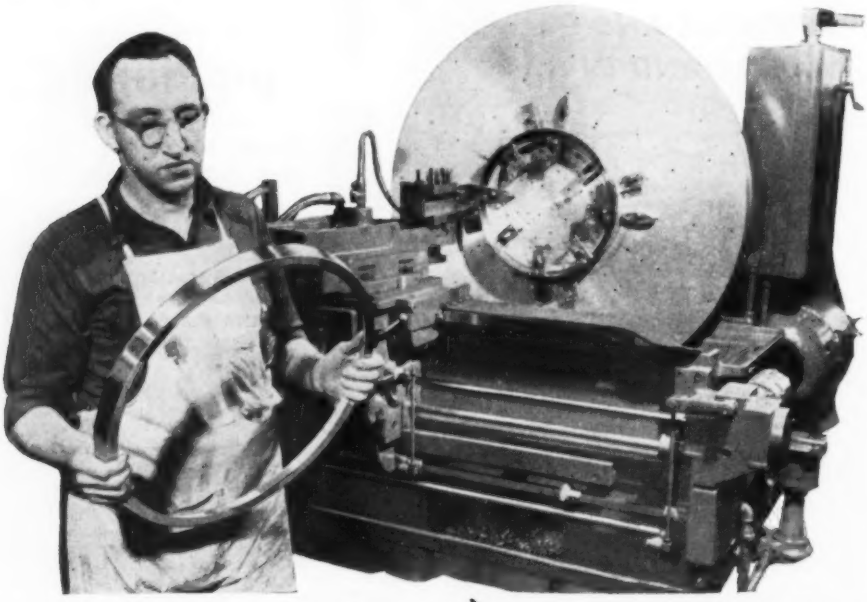
vanes and blades are identical in contour and root dovetail. This assembled ring goes into dovetail slot in housing, which holds vanes without doweling; blade slots are doweled.

This piercing of 64 slots in a vane ring measuring ⅛" thick, 3½" high and 32" in diameter is accomplished in 40 seconds, or at the rate of approximately 40 pieces an hour, on a 32-ton-capacity horizontal power press developed especially for the purpose. The fully automatic operation is accomplished by two slides, adjustable to punch either outside in or inside out, giving a controlled position to the burr. Floor-to-floor time is 1½ minutes. Press can be furnished with two types of index units, ratchet type for a fixed number of slots or a geared unit with change gears for any number of slots. It is manufactured by V & O Press Co.

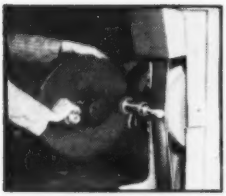
Machining Nozzle Vane Inner Support Ring

In machining thin-walled, stainless steel rings of large diameter for turbojet nozzle vane rings, stator shrouds and tailpipes, there has been dissatisfaction over the conventional big swing lathes, as was pointed out earlier. Jet

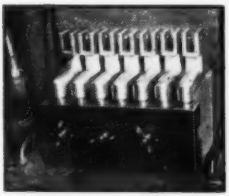
This workpiece, being turned on a Lodge & Shipley 60" right angle chucking lathe, is one of a number of similar parts which are machined on T lathes. This is a nozzle vane inner support ring turned from AMS 56-51 stainless. The cutting tool used for continuous cuts is carbide tipped. On the intermittent cuts (in the region of perforations) a high speed steel cutter is used. The 54" diameter aluminum face plate shown is clamped on the standard face plate of 25" heavy duty headstock. Straps and rods are used to hold the workpiece in position. Tolerances up to .001" are easily obtained. Lodge & Shipley's 30" T-Matic right angle chucking lathe is fully automatic with hydraulic tracer control and infinitely variable speed drive. It is used for fast, precise, automatic duplication of short, thin-walled section work of large diameter.



Do your machining up to 10 times faster!

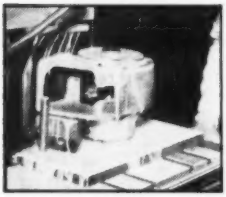


• Originally turned on lathe, now rough and finish-ground at 600 per hour.

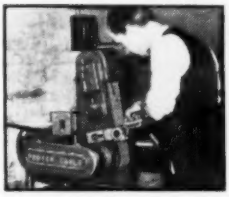


• These pieces formerly *milled* now belt-ground 5 times faster.

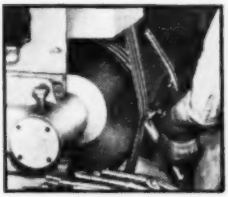
• Grinds broad areas flatter and faster than *radial surface grinder.*



• This grinding operation 100% faster than former *milling* time.



• Generates 2 radii at double the output by *hand filing* and *polishing.*



• Replaces *polishing jack* — eliminates costly setting up of glued wheels.

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Abrasive Belt Grinding removes stock rapidly, provides fine finish free of tool marks. Greatly simplifies fixtures — or eliminates them entirely. (Often makes hand presentation possible.) Is up to 10 times faster than milling, shaping, polishing or ordinary grinding — frequently saves 75% to 90% of previous set-up time.

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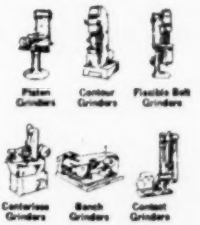

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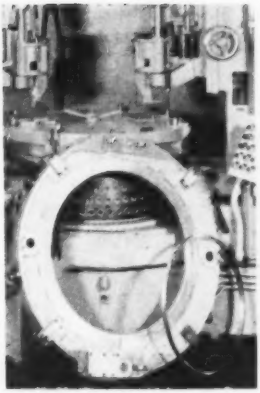


For drilling and reaming dowel holes in compressor shroud spacer rings, this machine developed by Snyder Tool & Eng. Co. is so arranged that it can be used for drilling any size ring from 16" to 39" in diameter. The cycle of the machine is controlled by an interchangeable drum which provides for the drilling of various hole patterns. The machine is capable of spacing the holes within a tolerance of ±.002".

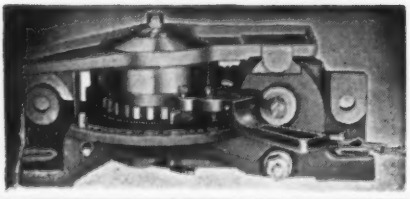
rings are shallow and of thin wall section and the cuts are light and precise, so the large horsepower of the heavy duty lathes isn't needed. However, diameters to be handled, running up to 48", require a large lathe capable of a 60" swing. Though the materials are new and tougher, the components are often flimsy to work with due to their large diameters and thin construction.

Various companies now manufacture a right angle chucking lathe that can handle facing, straight or taper turning or boring and can be purchased with a contouring attachment. As a second-operation machine to receive roughed-out work from a vertical boring mill, these are ideal answers when there is a shortage of the latter. The new design saves nearly half the floor space that would have been required by a standard 60" swing lathe.

Special chucks aid in machining turbine wheels, discs, rings

Along with the machining of large rings of small cross section, the problem arose of holding them without producing distorting strains in the workpiece. Companies such as Horton and Cushman have come through with sev-

MODEL H . . . AUTOMATIC CHUCKING and INDEXING FIXTURE



1. 1800 light cuts per hour.
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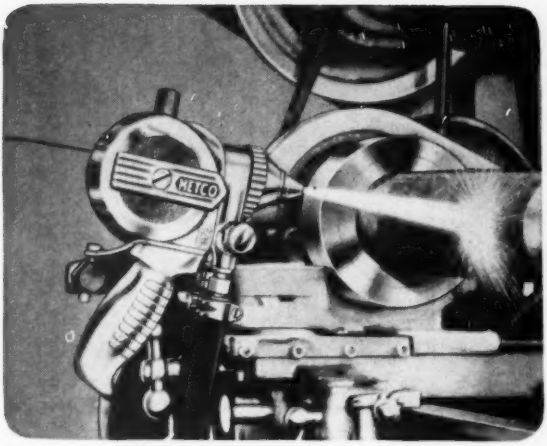
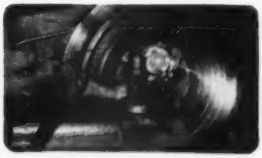


now a really low-cost metallizing installation...

with the new Metco L-Gun

Metallizing damaged journals on turbine shaft



Building up worn brake-drum

Metallizing protective coating on steel plate

New, low, compressed-air requirements . . . only 10 cfm at 40 to 60 psi, already available in many shops, or supplied by inexpensive 3 hp compressor . . . bring metallizing within reach of the small user.

Here's a chance for the smaller maintenance shop to get into profitable metallizing operations like these:

- Save up to 90% of replacement costs on machine repair jobs,
- Do your own hard-facing,
- Apply long-wearing corrosion-resistant coatings to exterior plant structures, tanks and other equipment.

Sprays 23 Different Metallizing Wires—With the new L-Gun you can spray .10, .25, .80 carbon steels, stainless, babbitts, brass, bronze, nickel, aluminum, tin, zinc, special hard-facing materials such as Metco-Weld H, and the new self-bonding Sprabond wire.

It's Versatile—Use the L-Gun machine-mounted or hand-held—it weighs only 4 lb. 2 oz. Do all kinds of metallizing work—shaft and bore build-up with harder, longer wearing metals; build up worn pump plungers, crankshafts, motor shafts; apply corrosion-resistant coatings. There are hundreds of different jobs that are "naturals" for metallizing.*

Same High Quality as Other Metco Guns—The low air requirements of the new L-Gun have been achieved without any sacrifice in Metco quality. It embodies new developments in turbine and nozzle construction—is built, like all Metco guns, for rugged, dependable service.

A Real Opportunity for the Smaller Shop—Thousands of large, well-known companies have been metallizing users for many years, not only in maintenance but in production applications on original equipment. Now, with the development of the new L-Gun, and a low cost installation, metallizing is within the reach of even the smallest plant. (We'll be glad to send you the names of some Metco users—large and small.)

Free Bulletin or Shop Demonstration—Send off the coupon for the detailed information Bulletin 55 gives you. Or, better still, ask for a demonstration in your own shop by a Metco Field Engineer. He'll be glad to show you how the new Metco L-Gun works on some job of your own. No obligation, of course.

See other examples of metallizing illustrated in our 8-page Bulletin in your Sweet's Plant Engineering File—Section 7a/Me.

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Adjusting-screw head is graduated into 50 divisions to provide readings in thousandths, and body is graduated to permit vernier readings of 0.0002-inch. The three models available have maximum boring bar capacities of 1/2, 3/4 and 1-inch and boring range from 3/8 to 15 inches.

988-MC

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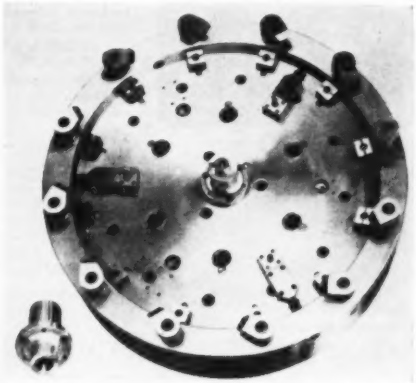
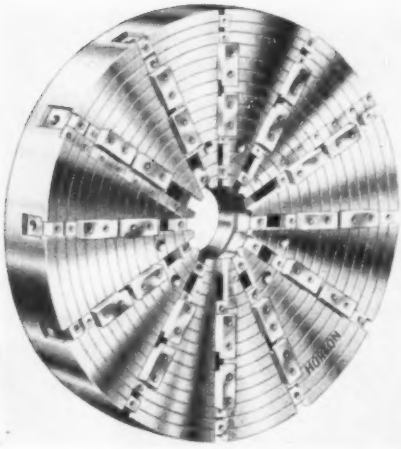
THE MAXWELL COMPANY

220 Broadway • Bedford, Ohio

A Cushman 28" six-jaw chuck having one set of three contracting jaws opposed to one set of three expanding jaws. The contracting jaws are operated from an air cylinder attached to a wedge which in turn is operably attached to cylindrical radially moving bars. Any movement of the radially moving bars is transmitted to the contracting set of jaws through levers. This set of contracting jaws has gripping faces that are always concentric with the center of chuck or spindle to which chuck is attached.



A **30" twelve finger** type operated by a double acting rotating air cylinder. The cylinder is attached to the draw tube at the rear of the spindle and not to the spindle itself as in standard application. This is made by Cushman.

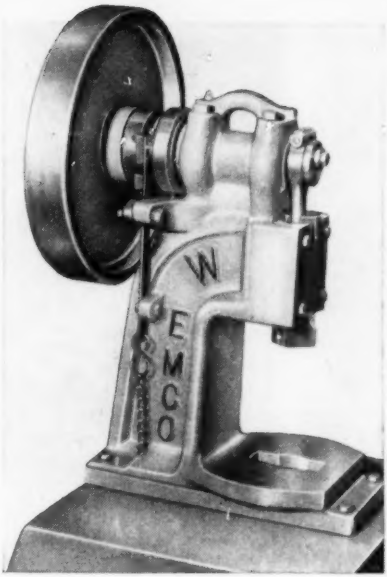


Pinch type chuck especially designed for first and second operation machining on out of round or stress relieved parts such as shroud rings, rotor compressor discs, turbine compressor discs and other thin walled sections. It is made by Horton.

eral new developments, some of them included here.

Cushman has first operation, 3-jaw special self-centering turbine wheel chucks, in which the self-centering jaws are lightly gripped in the o.d. of the skirt of the workpiece. Upon each self-centering jaw is a jaw having an adjusting screw which permits these latter jaws to be securely locked against the workpiece directly opposite the grip already lightly taken by the self-centering jaws. Thus the grip of the jaws does not distort the workpiece.

A 42" chuck designed for holding large rings of small cross section has inside and outside jaws, either of which can be fixed, with the other free to move by revolving the operating screw. Essentially the chuck consists of a 42" diameter aluminum one piece body with 12 radial slots equally spaced. In each slot there is permanently bolted and doweled a steel jaw base which carries the master jaws and operating screw all as a unit in a T-slot provided for that purpose.



Emco "W", bench type. Also Emco "X" (larger size). Both sizes also stand-mounted. With or without motor drive.

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Versatile Emco presses excel for punching, forming, stenciling and riveting metal, rubber, leather, plastics and other nonmetallic materials. Up to 300 operations per minute. Big machine speed, strength, rigidity, accuracy and endurance. Compact, fool-proof, two practical sizes, simple design—easy to operate. Thousands of Emcos in money-making use testify to Klaas' dependability since 1921.

Emco "W"—¾", 1" and 1¼" strokes.
Emco "X"—1½" and 2" standard strokes.
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Tells how you can easily, quickly, economically balance rotors, armatures, crankshafts, and any other part that turns, weighing from 4 oz. to 8 tons! See how to reduce wear, eliminate noise and vibration, improve all-around performance of finished product. Your copy sent without cost or obligation. Bear Mfg. Co., Dept M-20 Rock Island, Ill.
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"BEAR"
STATIC AND DY-NAMIC BALANCING MACHINES
balance rotating parts weighing from 4 oz. to 8 tons

Their 30" 12 finger chuck is operated by a double acting rotating air cylinder. The cylinder is attached to the draw tube at the rear of the spindle and not to the spindle itself as in standard application. Chuck and cylinder are self-contained with the forward end of the draw tube attached to the chuck plunger. The purpose of such a unit is the ability to machine large turbine wheels of varying thin sections without fear of distortion or straining workpiece.

The flange-type expanding ball arbor is for internal chucking of workpieces for either turning or grinding operations. It is designed for second-operation work where extreme accuracy in centering is a necessity. The arbor can be mounted directly to the spindle nose or by means of an adapter, and is operated by a rotary cylinder mounted on the rear of the spindle. Because of practically unbroken surfaces, these will not mar even soft metal.

A new chuck specially designed and

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DOUBLE UTILITY
Ideal Lighting for Assembly Repair and Inspection Benches
FOSTORIA
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MODEL 18HX600
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Overall length 27½" with 18" flexible steel tubing arm
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DUPLEX OUTLET IN BASE for plug in of electrical tools, glue pots, etc.
Clamps to bench or cabinet back rail, or mounts on flat surface.
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Illumination — medium asymmetric in excess of 150 footcandles from 100 watt lamp 12" above work area.
Wired Complete with medium screw keyless porcelain socket and 6 ft. SJ extension cord. Toggle switch in base. Duplex outlet wired to be constantly hot with lamp on or off.
Finish — exterior smooth Gray baked enamel—reflector interior high temperature White.
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developed for first and second operation machining on jet parts is being manufactured by Horton. Designated as J-type, it is a 12 jaw chuck in which three jaws are universal and nine independent. It is a pinch type in which a double set of jaws is mounted in each jaw way. As the jaws are moved toward the work, the first jaw stops automatically upon contact with the piece and the mating jaw continues to travel until a firm grip has been established. On stress relieved or distorted parts, this quick locating feature is important, since the three jaws float and can be run in quickly by hand to center the piece, while the nine independent jaws move up to grip the part in its "as is" position. The chuck is available in standard sizes up to 46".

The six jaw J-type was developed for use on right angle lathes. Single purpose jigs, fixtures and special holding devices have been practically elimi-

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EXTENSION SOCKETS. To convert and extend spindles to smaller and larger Morse Taper also making it possible to reach machining locations where needed. For use on multiple spindle applications, drill presses, radial drills, turret lathes and other machines.

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nated by this chuck. This scroll combination is very versatile. The six jaws may be operated independently or in any combination. Master jaws are flush with the face of the chuck and are T-slotted for attaching various holding or clamping devices.

Horton also manufactures three jaw universal scroll and four jaw independent chucks from 32" to 46" in diameter for turning jet parts. Chucks can be furnished in forged steel, semi-steel or aluminum.

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...b

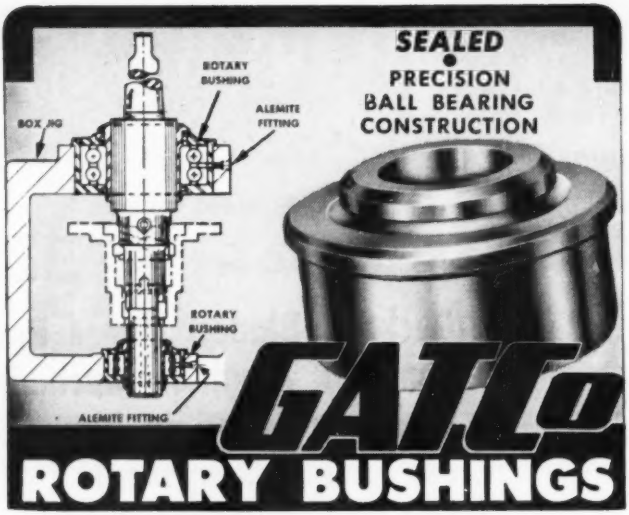
Buckets, Blades, Vanes Present Some of Toughest Machining Problems Found in Manufacturing Jet Engine Components

PERHAPS THE MOST important parts of the turbine that bring the most exasperating problems to the machinists and tool engineers are the buckets and blades. Because of their importance to the over-all performance of an engine and the great number of special machines developed for their many phases of manufacture, these and related components will be dealt with more in the following articles than will some other parts of the jet engine.

Blades give a great deal of trouble because of their complicated airfoil shapes and required high quality, tolerances of 0.003" sometimes. Also, because of the large number of blades needed in each engine, around 2000, production costs are necessarily of immediate consideration. A surface finish of 10 microinches rms is often required. The buckets, because of the extreme toughness of the high-temperature alloys used and the intricate mechanical fastening to the wheel (known as the Christmas or pinetree dovetail), give their share of problems too.

Since the more powerful, many-bladed, axial flow compressor, rather than the one-piece, centrifugal compressor, seems to be the trend, the blade problem becomes even more acute.

Close tolerances (to within 0.003"), large numbers needed in each engine (around 2,000), extreme toughness and hardness of materials, variety of complicated airfoil surfaces.



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Eliminates expensive tool construction—Reduces tool wear—Prevents seizure and pilot breakage—Especially adapted where precision is required.

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Three processes are generally being used in the manufacture of blades and buckets, with exponents of each method loud in defense of his own: forging, both wide-limit or precision forging, plus finishing operations; machining from the bar; and investment-casting plus finishing.

Rotating blades or buckets are almost always held in the discs by a mechanical fastening. This includes serrations, or the pinetree, roll and many other forms. These must be made accurately in form and tolerance to fit the mating slots broached in the turbine disc. This base mating section is most often ground although some are currently being broached. Many special machines have been developed; essentially these consist of two mounted wheels, with a sliding fixture which carries the piece between the wheels. Compressor blades are either ground,

Untrained girls produce 'Class 3' threads on any drill press with "Auto-tap"

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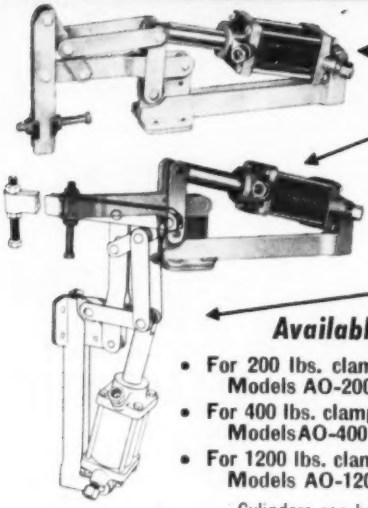
broached or milled.

Some of the most extensive development work in the field of special machines for processing turbojet engine blades and rotor wheels has been carried on by the Ex-Cell-O Corp., Detroit. After intensive research and experimental work on the machining of stainless steel blades for jets, late in 1950 the new Style 85 precision two wheel form grinder was announced. This machine was designed for grinding simultaneously both sides of forms such as the roots of jet engine blades and buckets. The next year, in July, Styles 86, 87 and 88 profiling machines were announced, and the Style 84 in May. The plane surface at the base of the blade root is ground on an 84 precision surface form grinder. The machine uses a 12" grinding wheel mounted vertically above a reciprocating work slide, hydraulically operated and electrically controlled. One to three blades can be

HAVE YOU HEARD ABOUT AIR-OPERATED TOGGLE CLAMPS
to step up your clamping operations?



Knu-Vise (AODT-400)
Double-toggle Clamp to clamp "around the corner"

Knu-Vise (AO-400)
Toggle Clamp for conventional clamping.

In cases where the cylinder interferes with conventional clamping, the Double-Toggle Clamp shown at the top serves such difficult mounting situations as illustrated in the superimposed line drawing.

Available in 3 series

- **For 200 lbs. clamping force**
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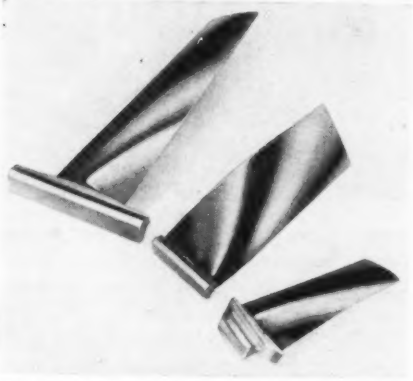
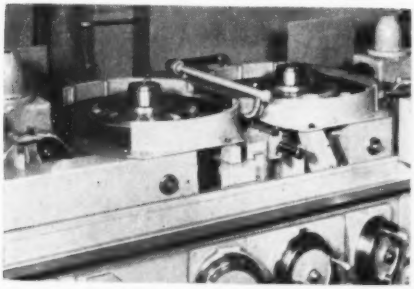
accommodated at once. Grooved and curved surfaces, as well as plane areas, can be ground. Changing the dresser cam, installing a suitable grinding wheel and adjusting the automatic cycle are the three steps needed to change from one form to another.

The three special automatic production machines for finishing the airfoil of jet engine blades, Styles 86, 87 and 88, are miller, grinder and polisher, respectively. The 86 does the first operation on the airfoil of the blade, milling the complete form, including leading and trailing edges and root fillet. Roller type backrests support the work rigidly throughout the cutting stroke. The 87 grinds the complete form, including leading and trailing edges and the root fillet. A precision grinding spindle with its drive equipment is mounted on an angular slide on the front of the machine base. The 88 uses an abrasive belt to polish the complete airfoil form

except the leading and trailing edges. On all these profiling machines, the movement of the work head is controlled by a cam.

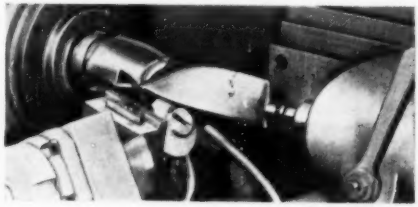


Typical forms of jet engine blades.



View of grinding compartment of the Ex-Cell-O 85, showing grinding wheels and a fixture containing two blades on the work-slide between the wheels.

These are types of fixtures for holding blades during operations on the Style 84 surface form grinder and the 85 two-wheel form grinder.



View of compressor blade with extreme twist, in machining position in the Style 87 profile grinder.

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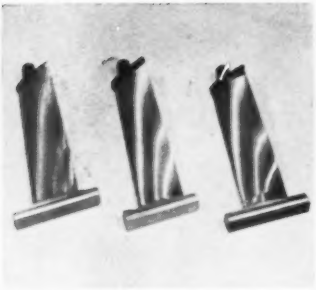
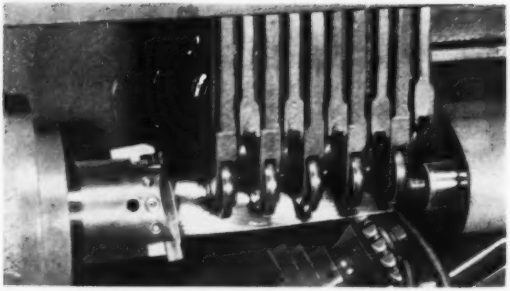
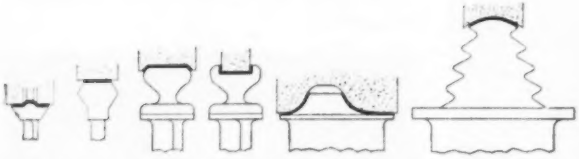
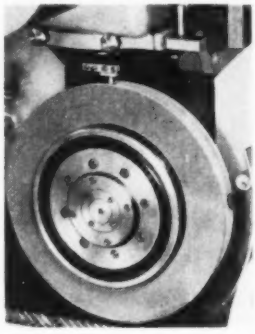




Airfoil operation number one is milling the complete form, including leading and trailing edges and the fillet where the airfoil joins the root platform. The larger picture shows a jet compressor blade in working position. The work reciprocates between two 24" grinding wheels which are diamond dressed as part of the automatic cycle, on the Style 86. Steadyrests prevent deflection of the blade while the carbide tipped cutter is working. The photo of the blades illustrates how, left to right, respectively, the three Ex-Cell-O profiling machines mill, grind and polish.



Drawings of the roots of jet blades and buckets showing in heavy lines surfaces that can be finished in an automatic cycle on the Ex-Cell-O Style 84 precision surface form grinder. The photo shows a grinding wheel dressed to do the work shown in the second drawing from the right. The wheel is shaped by a diamond dressing tool which is above the vertical wheel.



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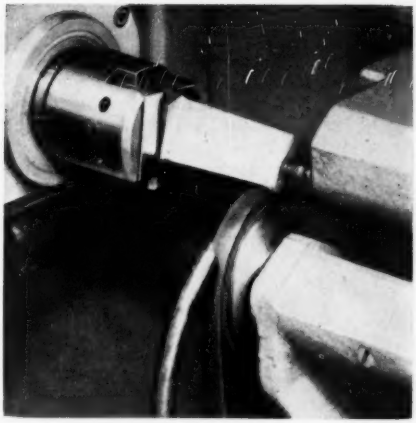
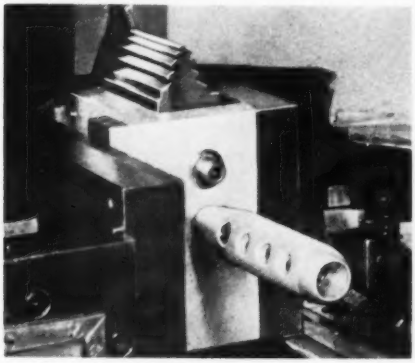
Close-up of grinding wheel and dresser, Style 85 Ex-Cell-O two wheel form grinder.



Polishing the airfoil form of a jet compressor blade on an Ex-Cell-O Style 88 precision profile polisher.



Here the pinetree form on the root of a jet turbine bucket protrudes from the work fixture. The fixture is on the reciprocating table between the horizontal grinding wheels of the Ex-Cell-O Style 85 two wheel form grinder.

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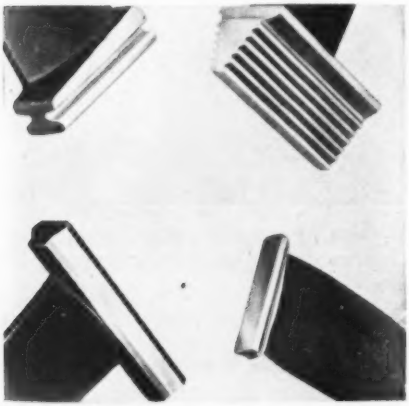
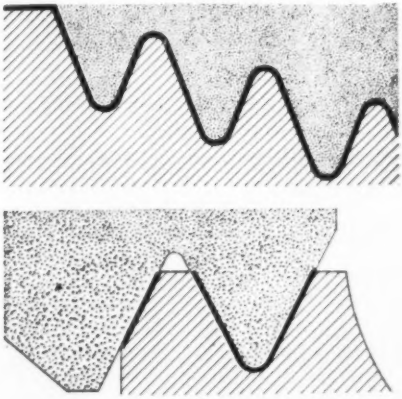
The second operation on a typical blade is grinding the sides of the root form. Both sides are ground simultaneously and in an automatic cycle on the Style 85 Ex-Cell-O precision two wheel form grinder. The work reciprocates between two 24" grinding wheels which are diamond dressed as part of the automatic cycle. Two dressers shape the wheels to grind straight or curved dovetail or pinetree forms. With the base and sides of the root form completed, one end of the root is milled and the nib on the airfoil end is center-drilled. Three points are thus established for locating and clamping in all the subsequent machining operations. This photo shows some of the various root forms ground on this machine.





Often the key to accurate, fast contour grinding is a good manual or automatic wheel dresser. Many companies, such as Hoglund, manufacture a wide variety of dressers, both special and regular, for surface, gear and cylindrical grinding machines. Pinetree forms at the base of a jet engine bucket (top), has a combination of convex and concave surfaces difficult to put into a grinding wheel without a reliable dresser. Extremely fine tolerances are needed in a compressor-blade root form (bottom), for a close blending of radius and tangent.

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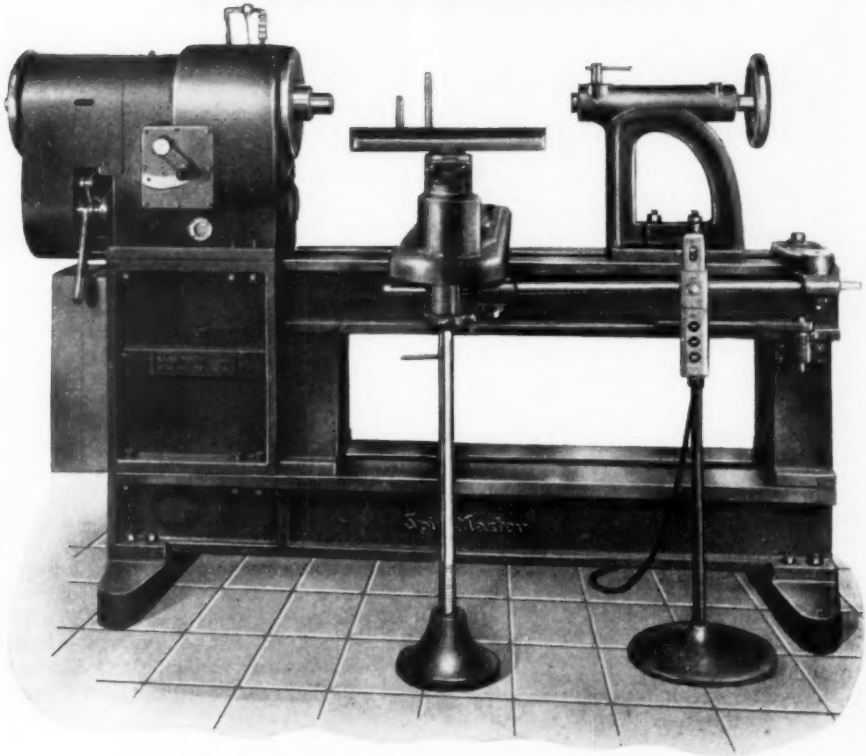

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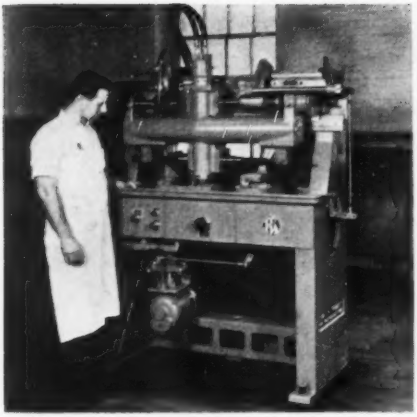

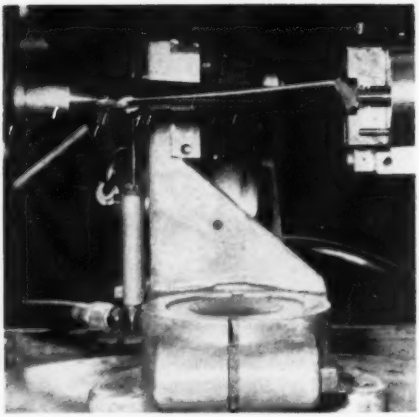

The P&W turbine blade airfoil grinder produces a profile section by copying an airfoil master cam. Stock is removed from the work by a high speed abrasive belt. The operating principle is the same as that used in the familiar gun stock lathe, but two new motions have been added: the grinding idler is swivelled by cam action so the grinding contact is always normal to the foil, produces the diagonal motion ing belt life; a compounding cam, timed with the work, produces the diagonal motion needed to grind parallel to the root of a blade whose axis is not parallel to its base. The closeup shows the entire twisted and irregular airfoil section of the blade, including leading and trailing edges, being ground in a single automatic operation on the machine.

To help speed production of jet blades and buckets, Pratt & Whitney developed an airfoil grinder for finishing sections to ± .003. The machine reproduces dimensions and shapes from a master. Any forged or fabricated blade up to 9" x 4", having any irregular and twisted airfoil section, is precision ground in a single automatic cycle. It utilizes the advantages of a high speed coated abrasive belt with a five cam system that controls shape, angle of grinding contact, variation of work rotation speed, compound motion for grinding to angular blade roots, number of passes and amount of stock removed in addition to speedy loading. The complete airfoil section, including the leading and trailing edges, is finished and smoothly faired regardless of the angle of the blade root.

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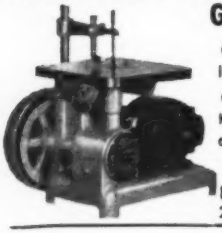

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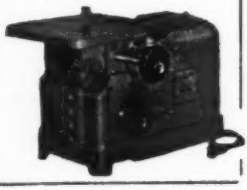

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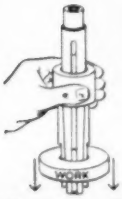

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Equipment for production grinding of the external airfoil surface of jet engine turbine blades including buckets, blades, vanes, nozzles, etc., has been developed by Norton Co. Known as the compound contour jet blade grinder, the blades are held on an arbor between synchronously-driven, left and right hand shape-producing units which impart the figure "8" motion to the arbor for grinding blade forms. The cams in each unit give a rise and fall to the machine's work spindle together with an in and out swinging motion for controlling blade shape. Arranging relationship of one unit to the other is possible because of this feature, so that the path of the rotating work spindles when supporting an arbor can cause a blade to be ground to a varying shape from one end of the piece to the other.

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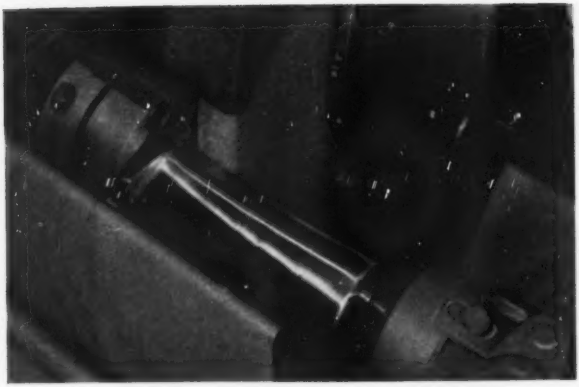
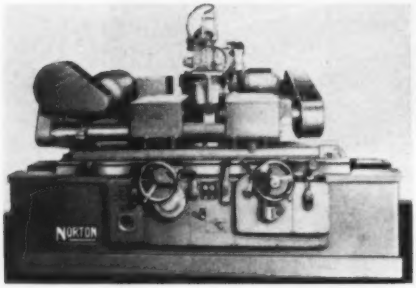
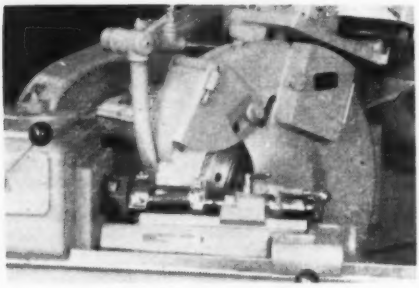
supported by ball-nose type centers which are held in the spindles of the shape-producing units, and is designed to suit the specific conditions of the blade and to support the blade at the required angle. Blade design determines the number that can be held on the arbor.

Parts having thrust surfaces and adjacent diameters that must be ground are handled in Norton's 6" x 18" and 10" x 36" angular wheel, semiautomatic cylindrical slide grinders. Because of their 30° feeding action, they grind these surfaces simultaneously, thus eliminating "shoulder bumping." The cycle requires only loading, pulling the control lever and unloading. The specially designed dual-work turrets supplied for this application of the machine permit as high as six surfaces to be ground at the same time; this represents three surfaces on each of the two blades which comprise a turret load.



This shows a setup for grinding the contour of a bucket on the machine developed by Landis for the uniform grinding of five surface elements of jet blades and buckets in one continuous operation.





Grinding of the external air foil surface of turbine blades is accomplished on the new Norton compound contour jet blade grinder, left. Parts having thrust surfaces and adjacent diameters such as tangs that must be ground, are handled in their angular wheel, semiautomatic slide grinders, right. Because of their 30° feeding action, they grind these surfaces simultaneously, thus eliminating "shoulder bumping."

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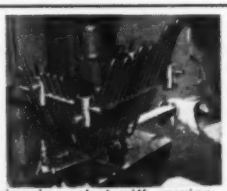

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5	30-32-36-48-80
6	36-40-48-56-60
7	32-40
8	24-30-36-38-40-44-48
9	24-28-32-40
10	28-30-36-40-48-64
12	20-28-32-36
14	20-24-28
1/16	60-64
5/64	72
3/32	48
7/64	48-56
1/8	32-40
5/32	32-36-40
9/64	36-40
11/64	36
3/16	20-24-32
13/64	32
7/32	24-28-32
1/4	18-24-26-27-30-32-36-40
5/16	16-20-22-27-28-32-40
3/8	12-16-18-20-27-28-32-36-40-48
7/16	12-16-18-22-24-27-28-30-32-36-40
1/2	12-14-16-18-22-24-26-27-28-30-32-40
9/16	16-20-24-27-28-30-32-40-48
5/8	12-14-16-20-24-27-28-32-36-40
11/16	11-16-18-20-24-27-28-30-32
3/4	9-11-12-14-18-20-24-26-27-28-32
13/16	10-14-18-20-32
7/8	10-12-16-18-20-24-27-28-32
15/16	8-9-10-12-14-16-18-20-24-32
1	10-12-16-18-20-24-27-32-40
1-1/16	12-14-16-18-20-24
1-1/8	8-10-14-16-18-20-24-32
1-3/16	8-10-12-14-16-18-20-24
1-1/4	8-10-14-16-18-20-24-32
1-5/16	12-14-16-18-20-24-32
1-3/8	8-10-14-16-18-20-24
1-7/16	8-10-12-16-18-20-24
1-1/2	8-10-14-16-18-20-24-28
1-9/16	18-20-24
1-5/8	5½-8-10-12-13-16-18-20-24
1-11/16	10-12-14-16-18-20-24
1-3/4	8-10-12-14-16-18-20-24
1-13/16	8-10-12-14-16-18-20
1-7/8	8-10-12-14-16-18-20-24
1-15/16	8-10-12-14-16-18-20-24-28
2	4-½-8-10-12-16-18-20
2-1/16	12-14
2-1/8	12-16-20
2-3/16	12-16
2-1/4	4-½-8-12-14-16-18
2-5/16	12-18
2-3/8	12-16-18
2-1/2	8-10-12
2-9/16	18
2-5/8	12-16-20
2-3/4	16
2-7/8	8-12-16
3	8-16
3-1/4	8-12-16
3-1/2	8-12-16
3-7/8	6
4	8-12

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SIZE	THREAD
0	[illegible]
1	56-64-72
2	56-64
3	56
4	32-36-40-48
5	40-44
6	32-36-40
8	32-36-40
10	24-30-32-40
12	24-28-32
1/4	20-28-32
5/16	18-20-24-28-32
3/8	16-24-32
7/16	14-20-28
1/2	12-13-20-28
9/16	12-18-20-24
5/8	11-12-18-20-24
11/16	11-16-24
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1-1/8	7-12
1-1/4	7-12-16-18
1-3/8	6-8-10-12-16-18-20-24
1-7/16	8-10-12-14-16-18-20
1-1/2	6-8-10-12-16-18-20
1-9/16	8-10-12-16-18-20
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1-13/16	8-10-12-14-16-18-20
1-7/8	8-10-12-14-16-18-20
1-15/16	8-10-12-14-16-18-20
2	4½-10-12

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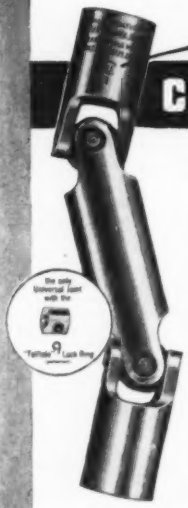

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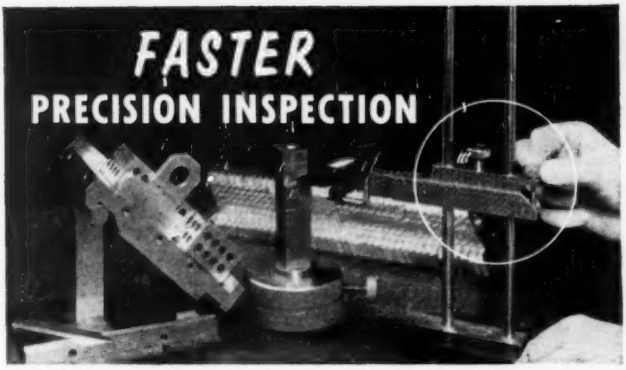

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with profile bar is used to produce the shape on the wheel. Semiautomatic operation permits one operator to run a battery of machines.

Another machine, the CHW, a universal grinder, was one of the first developed by Landis especially for jet parts. It handles such jobs as grinding the tips of blades after assembly on the rotor disc, grinding of tubine shaft after assembly with the wheel, tips of replacement blades in a compressor rotor assembly, etc.

A special six-spindle [illegible] milling machine with automatic [illegible] control unit for longitudinal movement of machine table and with power cross movement for the spindle carrier has been developed by Cincinnati Milling. It is equipped with six rotating work heads and the [illegible] rate of [illegible] the table [illegible] nearly constant feed rates maintained on the blade surface.

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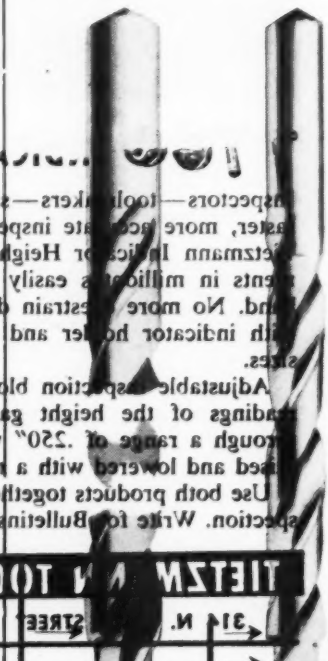

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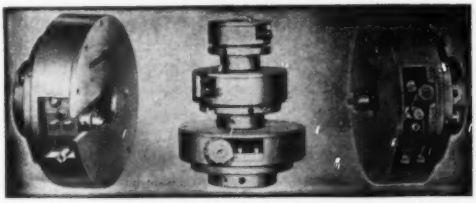

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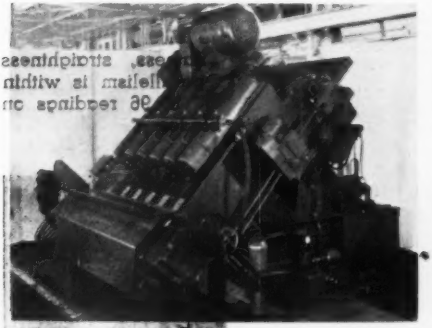
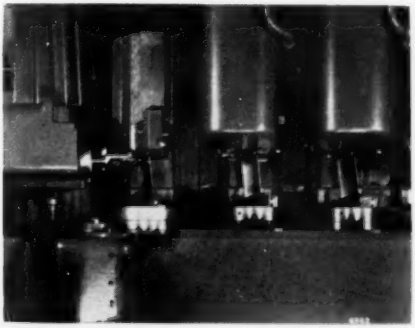
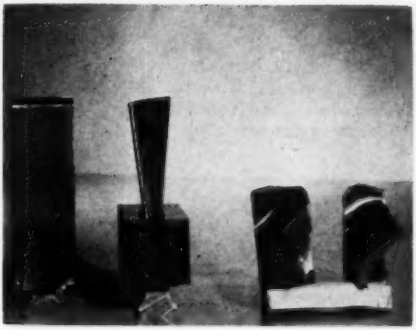


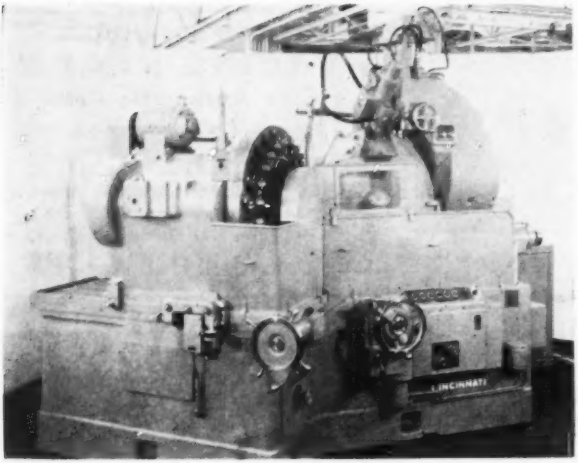


Blade milling machine developed by Cincinnati Milling Machine Co. The special six-spindle machine is shown along with a closeup of three blades in place. The other illustrates various stages in the milling of a blade.

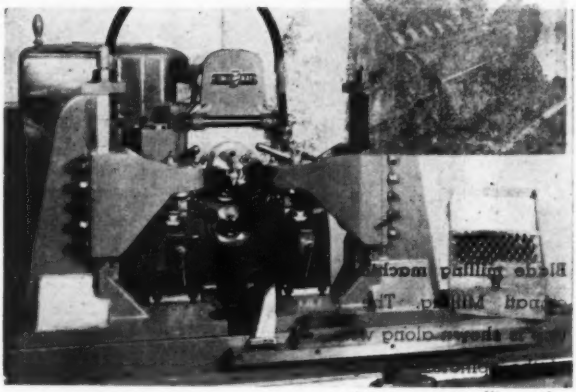


The machine is inclined 45° to allow easy loading and unloading of the work fixtures. A slight lateral movement of the machine spindle is provided through a compensating tracer arrangement to automatically overcome any error caused by the necessary deflection of the tracer finger. This compensating tracer arrangement allows a greater tracing rate and accuracy.

Spindle speed range is sufficient for either high speed steel cutters or Tungsten carbide tipped cutters. Using carbide cutters, average feed rate varies from 12" per minute to approximately 40" per minute, depending on the blade contour and material. Blades up to 16" in over-all length can be milled.



A difficult problem solved through the use of this special Cincinnati angular wheelhead grinding machine, and special tooling, was the grinding of five surfaces and two radii of the root tang on second stage turbine stator blades. Limits within .0005" must be held on flatness, straightness and parallelism. Production of 48 blades per hour is achieved. Accuracy is well within the specified limits. The cumulative error in the check for flatness, straightness and parallelism is within .0005" in 96 readings on 24 blades.



No. 2-24 automatic Cincinnati miller developed for milling radius on end of airfoil of blades and buckets and milling the 3/16" wide slot in the decks of bucket blades. It has special hydraulic circuit so spindle carrier can feed up instead of normal down feed, allowing cutter to pass under work.

A special station type grinder for grinding the surfaces and radii of the root tang on second stage turbine stator blades has been developed at Cincinnati Milling. It has an angular wheelhead and rotary fixture in which 24 blades can be ground at one time. A conveniently located jog button speeds up fixture loading.

In addition to an increase in production, the design of this equipment makes the accurate machining of the radii and surfaces possible. This accuracy is important in order to insure the correct fit between the stator blade and the stator ring. In order to achieve the specified surface finish and meet the required production on these abrasive-resistant, non-ferrous, "Nimonic 80" alloy blades, it was necessary to develop a special free-cutting precision grinding wheel. This wheel is of a grade which enables the grinder to hold the radii and at the same time meet the production and surface finish requirements.

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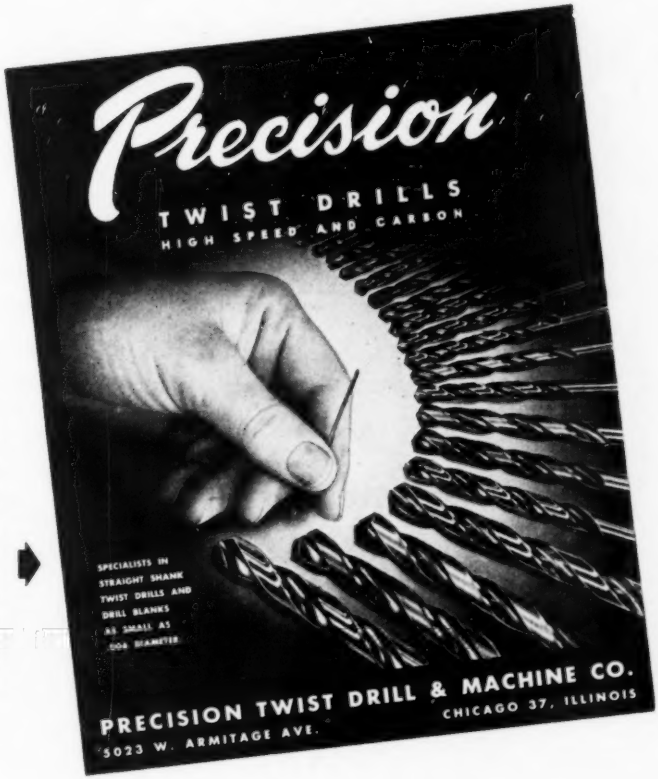
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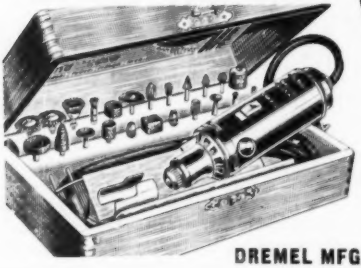

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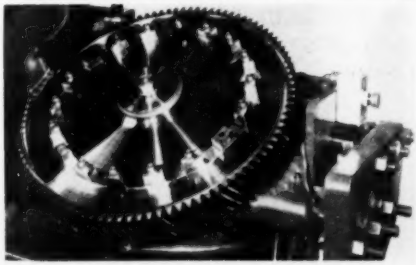
Close-up of pine tree slots in turbine rotor, broached by Cincinnati vertical single ram Hydro-broaching machine. The machine is equipped with a special variable delivery pump in order to obtain the very low broaching speeds required for the broaching of the heat resistant type of stainless steel used for the discs. The fixture shown in the photograph is tied in with the machine cycle and is initially hand clamped immediately after loading of the work into the fixture.



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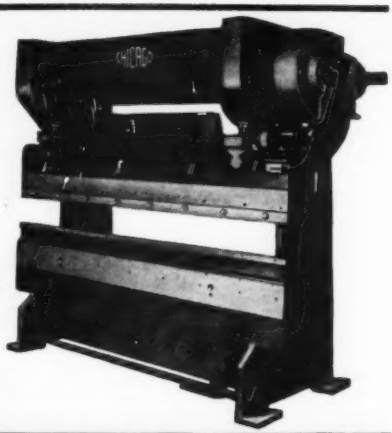

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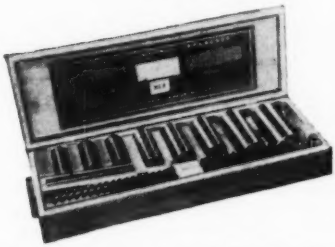

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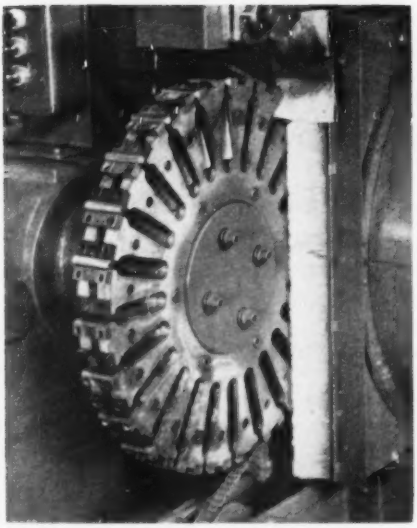
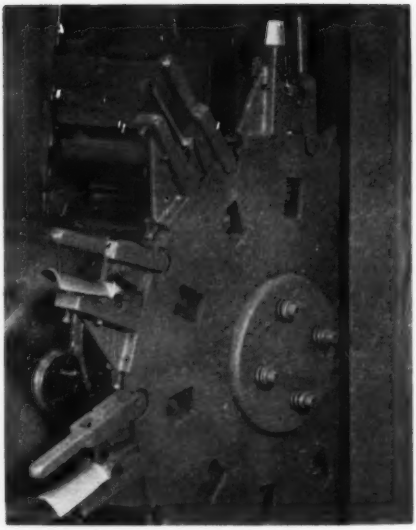
Extensive work has been carried on by Gardner Machine Co. in the development of special precision disc grinding machines for the jet engine program. Most of the units are for operations on buckets and blades.

The No. 125-26" double spindle turbine blade grinder rough grinds the parallel ends of turbine blades on a high production basis. These ends are cleaned up preparatory to a hardness test made on the ground surface. A rotary attachment carries a work carrier having approximately 26 slots into which the blades are manually loaded. A chain hold-down attachment holds the workpieces into the carrier during the grinding operation. They unload automatically after leaving the hold-down. A vari-speed drive on the rotary attachment permits varying the speed of the work carrier within a 3 to 1 ratio. Production is at the rate of 20 to 25 pieces per minute, removing 1/16"





Left, closeup of No. 125-26" double spindle turbine blade grinder by Gardner. The unit is set up for rough grinding the parallel ends of turbine blades on a high production basis. On the right is the same machine with hand clamping rotary carrier for grinding parallel ends of the pinetree on turbine buckets. It can also be used with V-block slotted rotary carrier and chain hold-down for grinding parallel ends of blades. Accuracy is .003" for uniformity, .0005" for squareness; production 90 to 100 pieces per hour for the latter.

maximum stock per end.

The No. 77A-12" double spindle grinder with hand operated swinging arm and special hand-clamping fixture is used to grind parallel ends of steel turbine blades; 350 pieces per hour; stock removal, 1/16" maximum over-all. Grinding two parallel ends of pinetrees is also accomplished on this machine. Stock removal is approximately .075" to .150"; 85 to 95 pieces per hour.

Gardner's No. 226-26" with special right hand screw feed table and hand pivoting fixture grinds the radius on the end of turbine buckets with an output of 90 to 100 pieces per hour. With a rotary table and special clamping fixtures, output is four to six pieces per minute.

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6	36-40-48-56-60
7	32-40
8	24-30-36-38-40-44-48
9	24-28-32-40
10	28-30-36-40-48-64
12	20-28-32-36
14	20-24-28
1/16	60-64
5/64	72
3/32	48
7/64	48-56
1/8	32-40
5/32	32-36-40
9/64	36-40
11/64	36
3/16	20-24-32
13/64	32
7/32	24-28-32
1/4	18-24-26-27-30-32-36-40
5/16	16-20-22-27-28-32-40
3/8	12-16-18-20-27-28-32-36-40-48
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9/16	16-20-24-27-28-30-32-40-48
5/8	12-14-16-20-24-27-28-32-36-40
11/16	11-16-18-20-24-27-28-30-32
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13/16	10-14-18-20-32
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1-3/16	8-10-12-14-16-18-20-24
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1-5/16	12-14-16-18-20-24-32
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1-5/8	5½-8-10-12-13-16-18-20-24
1-11/16	10-12-14-16-18-20-24
1-3/4	8-10-12-14-16-18-20-24
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1-7/8	8-10-12-14-16-18-20-24
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2-1/16	12-14
2-1/8	12-16-20
2-3/16	12-16
2-1/4	4-½-8-12-14-16-18
2-5/16	12-18
2-3/8	12-16-18
2-1/2	8-10-12
2-9/16	18
2-5/8	12-16-20
2-3/4	16
2-7/8	8-12-16
3	8-16
3-1/4	8-12-16
3-1/2	8-12-16
3-7/8	6
4	8-12

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SIZE	THREAD
0	80
1	56-64-72
2	56-64
3	56
4	32-36-40-48
5	40-44
6	32-36-40
8	32-36-40
10	24-30-32-40
12	24-28-32
1/4	20-28-32
5/16	18-20-24-28-32
3/8	16-24-32
7/16	14-20-28
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1-3/4	8-10-12-14-16-18-20
1-13/16	8-10-12-14-16-18-20
1-7/8	8-10-12-14-16-18-20
1-15/16	8-10-12-14-16-18-20
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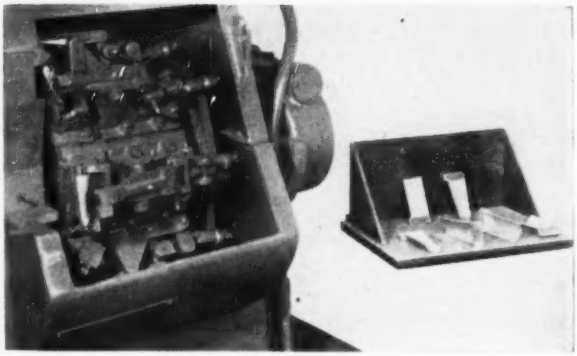


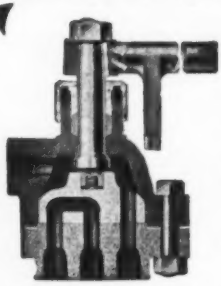
No. 122-23" semi-automatic Gardner grinder with cam clamping fixtures for grinding the trailing and leading edges of turbine buckets. Approximate stock removal is up to 3/32", with accuracy of plus or minus .008". Production is four to six surfaces, grinding edges parallel to root ends.

A new method of grinding buckets and blades has been developed by the Planet Products Corp., in their generating belt grinder. In cooperation with Metcut Research Associates, they designed and built the first developmental grinders for Metals Processing Div., Curtis-Wright Corp.

Tooled for Sapphire turbine rotor and stator parts, they have removed stock from one side of blades at a rate of .001" to .003" per second, so that an average cycle time of less than one minute per side is claimed. An 80 grit belt has been used on the rough or semi-precision Nimonic (about 80% nickel) forgings to produce approximately a 50 microinch finish.

This Large Processor

Chooses Nicholson Valves for LONG WEAR



A large rubber firm reports that Nicholson cylinder control valves recently completed 10 years of constant use, without servicing, on an operation which had proved too much for other tested units. This report further confirms that Nicholson valves, with their specially treated hard seats and non-corrosive lapping flat discs, become tighter with use. For air, gas, oil, steam, water in lever, foot, solenoid and motor types. Press., 300 to 5,000 lbs.

CAT'G 552

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W. H. NICHOLSON & CO.

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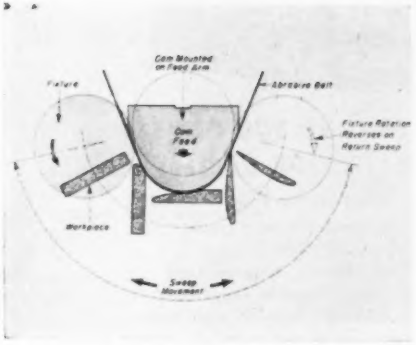

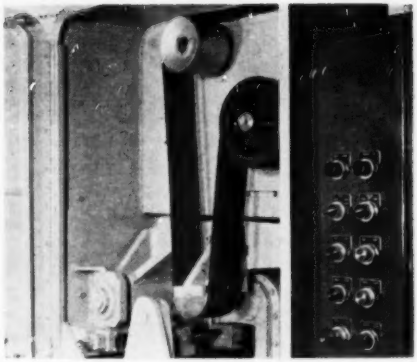

Generating belt grinder introduced by Planet Products. Basic motion and belt path to generate a simple airfoil shape is shown in photo and drawing. In the latter, the center circle represents a gear mounted in fixed position on the axis of the sweep arm. The outer circles represent the planet gear at its extreme positions at opposite ends of the sweep motion. Stock is removed at a sweep rate of about one cycle per second. The belt can be quickly replaced with the sweep arm in loading position; feed arm and belt are retraced. Outboard (tip) end of work piece is supported by chisel-point which is applied and released with light impact blow.

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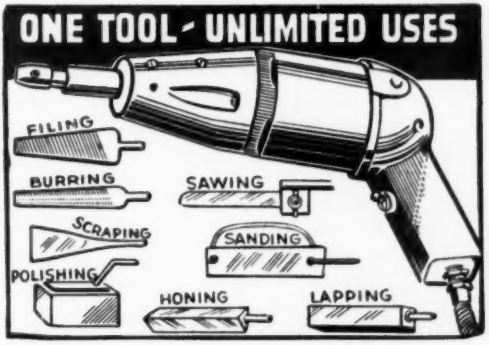
Use these Handy PORTABLE ELECTRIC RECIPROCATING TOOLS for Greater Production, Better, More Uniform Work — All with less Operator Fatigue. Fixed strokes are 1/8" or 3/8" long. Operate on 110 volts AC-DC. Deliver 1000 PUSH-PULL strokes per minute.



Try one of these tools on your next job.

ACME TOOL COMPANY

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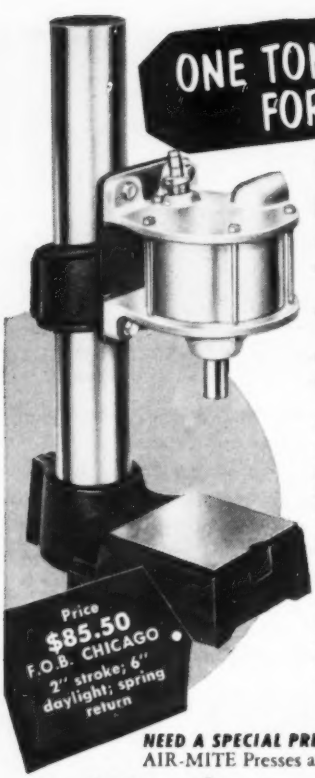

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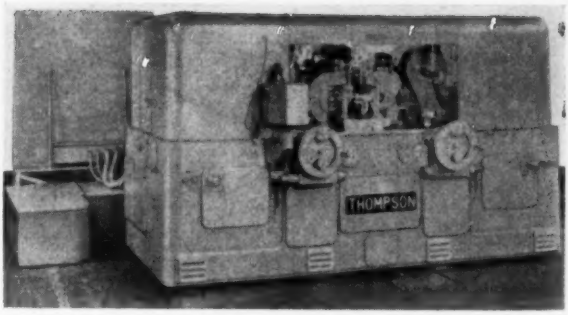
The method makes possible the rapid removal of sufficient stock to produce the required contours from comparatively rough work pieces, eliminating the need for high-precision forgings or castings. Once the machine is set up, the operator loads a workpiece, presses the master cycle button and the operation is automatic to the point of removing the finished piece and inserting a new one.

Automatic contour grinding of root sections on gas turbine buckets and blades, simultaneously, with two wheels dressed from a single crusher roll is accomplished by the new grinder developed by Thompson. Two advantages claimed are maximum production and low operating cost. While automatic in its operation, the Truforming machine controls and adjustments are simple enough to allow flexibility in



Root Sections on gas turbine buckets made of heat resistant material are ground on both sides simultaneously with the Thompson double wheel bucket and blade grinder. At .150 of stock removal per side, it can product at the rate of 30 buckets per hour. The bucket is preferably held in a matrix holding block using the solid anchorage method with accurate location of the bucket from projection.

the choice of method of production. The most important function of grinding the parts is to get absolute symetrical form on the root section about its axis. This is claimed for the common truing device employed, rather than diamond dressers on each wheel.

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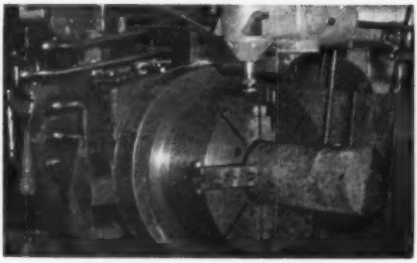
FEN

"4 JAW INDEPENDENT CHUCK OPERATION"



Illustrated above is a Model 12M operating a 24" heavy duty 4-jaw independent chuck.

For detailed information regarding the application of the Fen Automatic Wrench to your machines, phone, wire or write.

The Fen Automatic Wrench is designed to accurately locate the work piece by controlling the movement of each jaw. After the work is centered the Fen Wrench will grip the work to the desired pressure.

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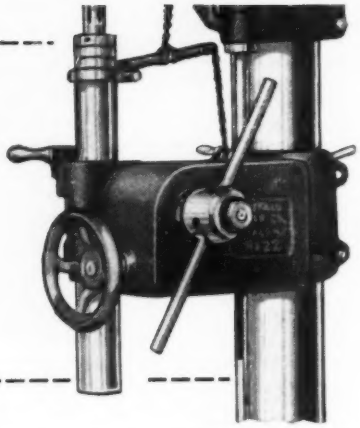

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Eight feet high . . . 1¼ capacity in mild steel . . . yet this big drilling machine handles almost without effort. That's because "Buffalo" designs all controls and adjustment cranks from the operator's viewpoint . . . easy and quick to reach in natural, relaxed position. This means less waste motion, fewer rejects, higher output during the production day. Available with power feed (shown at top) or sensitive feed, pedestal or round column, one to six spindles. And from spindle tip to base, these are quality drills built for many, many years "on the line." It may well be that a "22" is the answer to your profit problem. Why not write for Bulletin 2989-F, and see?

4-Spindle unit to handle 4 drilling and tapping operations at once or in sequence.

"Buffalo"

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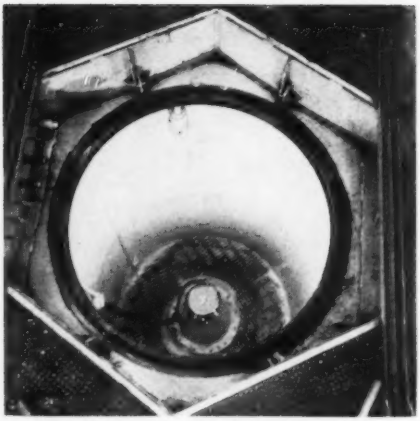
DRILLING PUNCHING SHEARING CUTTING BENDING

Array of Testing, Inspection Devices Developed for Jets

WITH 85,000 RPM not uncommon and much higher promised for the future, spintesting is a natural. What began as a design aid is now considered a must in testing such components as superchargers, castings and forgings, wheels, arbor gears, spindles, turbine rotors, compressor rotors, gyros, fan impellers, adherence or bond of plating to various parts when rotated at high speeds (sometimes over 100,000 rpm) and subjected to certain temperatures, etc.

Spintesting may be defined as the rotation of a part at very high speeds so as to subject it to abnormal centrifugal forces. The process is being used throughout the aviation industry in order to check the mechanical perfection and vibration characteristics of certain parts by spinning them at speeds substantially higher than would be encountered during normal operation. Deformation and plastic flow characteristics must be as carefully checked as those of vibration and safety. Failure of a high speed rotor in an assembly can result in destruction of valuable mechanisms, lost time and serious accidents. Rotors are costly and heavy. Various materials used in their assembly have varying deformation characteristics when subjected to high rates of spin, in varying heat conditions. Therefore, hot tests are used regularly now to simulate actual operating conditions. Heating apparatus consists of induction heating coils placed in such a position as to raise the temperature of the rims and blades to as high as 1500° F, while water jets keep the hub and web cool.

Precise requirements under increasingly greater operating stresses call for unique testing equipment; spin rotating parts at over 100,000 rpm to show bonding, plating adherence, vibration, deformation and plastic flow characteristics.



In spintesting a turbine rotor, the rotor is first mounted on a special test arbor which is equipped with two bearings spaced to fit the balancing machine. After balancing, the bearings are removed and the test arbor is secured to the turbine spindle. At this point the pit cover and drive turbine assembly is suspended from a hoist with the test arbor and turbine spindle in vertical alignment. The complete assembly is then lowered into the spinpit, care being taken that the magnetic chuck is de-energized, since the test arbor should not be suspended in perfect alignment from the turbine spindle. The spinpit consists of a cylindrical steel tank mounted in a vertical position, the upper end carrying a coverplate to which is attached the mounts of a drive turbine. A large model, manufactured by Warren Brothers Roads, is set in concrete with the top cover at floor level, while two smaller models may be bench mounted. The turbine used to spin the part may be either steam or air operated and is mounted on the top coverplate. Tanks are equipped with vaporproof lights and observation ports have been built into the coverplate. Speed is measured by an electric tachometer. In the event of a turbine spindle failure, the test arbor will drop into a conical shaped depression in the pedestal, thus allowing the arbor and test rotor to spin like a top until they eventually slow down and fall off the pedestal. A vibration pickup is installed so that an increase in amplitude of vibration can be detected. These shots were taken at Bridgeport-Lycoming.

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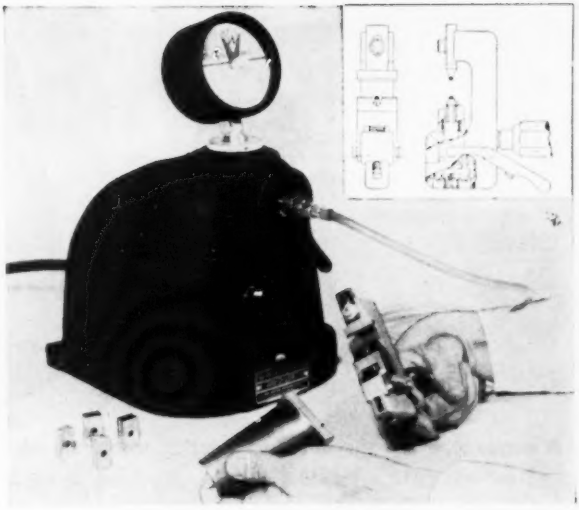
Two new gages that greatly speed the checking of external and internal pitch diameters of the root forms on jet blades and blade carriers have been developed by Pratt & Whitney. Both units are used as hand gages in conjunction with a standard Air-O-Limit Model F comparator. It incorporates an adjustable roll-type anvil. Opposite is the gaging point, a carbide ball point spindle that operates the single air nozzle.



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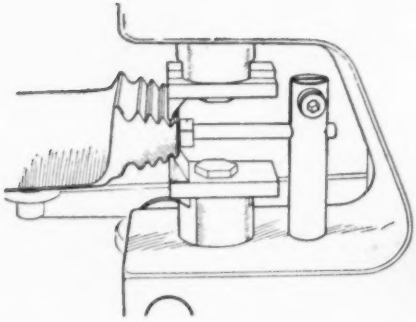
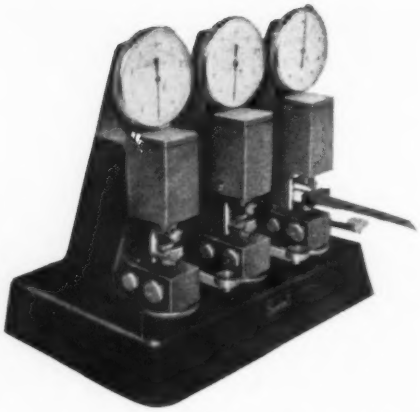
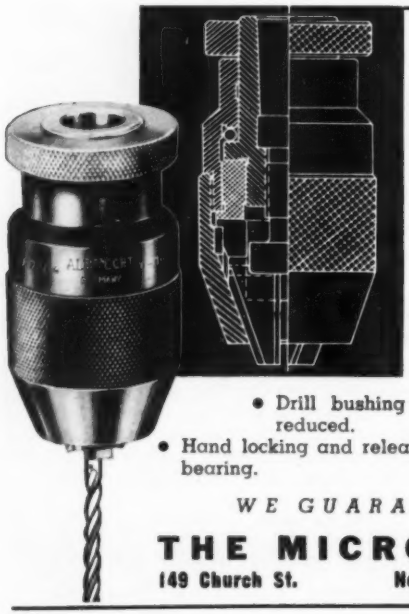




A simple type of blade-root comparator for measuring the pitch thickness of fir tree blade root serrations, that was developed in England, is being distributed by O-Vee Gauge Co. With this type of comparator, variations of blade root dimensions, from a master of known size, can be compared within 0.0001". The gage can be supplied with either two or three heads mounted on a common base for the checking of a number of serrations.



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"One-hand control" over all movable elements leaves the operator's other hand free to control rotation of the part being checked. Either headstock or tailstock can be unclamped, positioned and locked in place with a single hand operating the top lever. Investigate this bench center today.

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6" x 18"	12" x 48"	24" x 48"
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12" x 36"	12" x 72"	24" x 72"

FREE Additional Data

covering complete specifications and additional features is contained in this bulletin. Write for your copy. Ask for data sheet 440

SUNDSTRAND

SUNDSTRAND MACHINE TOOL CO.
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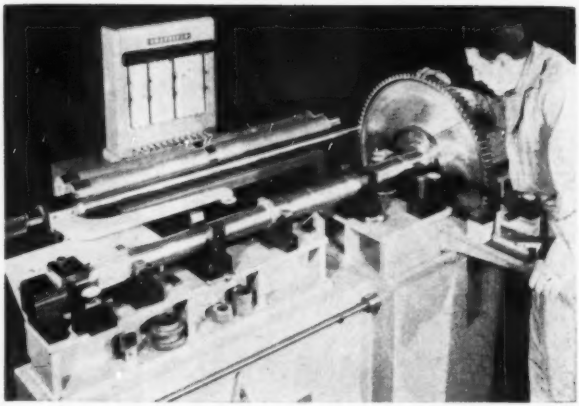
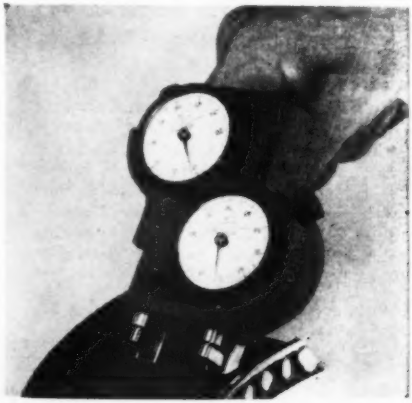
A turbine shaft and wheel assembly is accurately and rapidly inspected at several points by this type of Precisionaire gaging machine developed by Sheffield. Each inspection point has its own glass column in the "Airechart" for quick checking of tolerances. Points checked include: 2" dia. running from left end of shaft toward wheel—.003 t.i.r. concentricity of this bore diameter with the two outside diameters checked at six places simultaneously; inside dia. near wheel and the .003 t.i.r. concentricity inspected for diameter and concentricity; three outside diameters, one next to wheel, another in center, third near left end of shaft; .001 face runout of the 10.750 diameters; ± 17.149 .006 diameter over the buckets and the .0002 t.i.r. runout of the face of the 2.8125 diameter.



With the turbine shaft and wheel assembly gage made by Sheffield, an unskilled operator can check with sureness the following dimensions and conditions on the shaft and wheel: **(1) two inside diameters in the shaft; (2) three outside diameters on the shaft; (3) concentricity of each bore diameter with two outside diameters; (4) runout of wheel and shaft at four points; (5) radius over buckets on wheel.**

After the part is in position, the actual gaging of inside and outside diameters and concentricities is done with three air spindles, three Airsnaps and a 12 column Precisionaire. This huge gaging machine is especially effective in removing the possibilities of human error that are liable to occur when inspecting several dimensions on a large, hard-to-handle part.

This hand operated, portable Federal gage checks the minimum radius, at two locations, between adjacent blades of a jet engine turbine section. With contacts retracted, the gage fits between the blades ¼" from blade shroud to measure distance at a depth of .050" in from top blade edge. When contacts are released, the two dial indicators show immediately whether the blades are properly mounted in shrouds (for proper area). Operator influence and heat transfer has been minimized. Two other gages, not shown, Models 444B-228 and 229, check uniformity of spacing of slots or tongues on compressor discs which hold turbine blades and both location and depth of slots about periphery of compressor shaft, respectively.

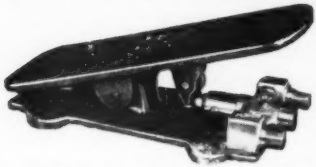


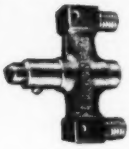
AIR DEVICES BY Redmer

REDMER INDEX CHUCK WITH AIR OPERATED COLLET

The Redmer Index Chuck Model No. RC-5 has 12 indexing positions and collet capacity of 1/16" to 2". Uses Brown & Sharpe type collets No. 22 and No. 11.

The Redmer Foot Control and Valve

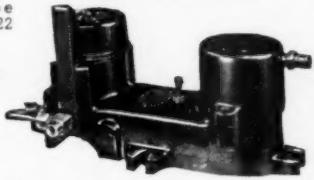




The Redmer Foot Control and Valve reduces operator fatigue in all cases where air control is necessary. Valve is a brass casting which can be removed and used as a separate unit with cam operations. Foot Control No. FC-28. Valve No. V-29.

Write for literature and prices

The Redmer Collet Air Chuck



The Redmer Collet Air Chuck is an air operated collet holding fixture using Brown & Sharpe type collets. Ideal for drilling, milling, threading and for assembly work. Equipped with air ejection for oil flushing. Capacities 1/16" to 3½".

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Controlling Pyrometers carried in stock — available for all applications.

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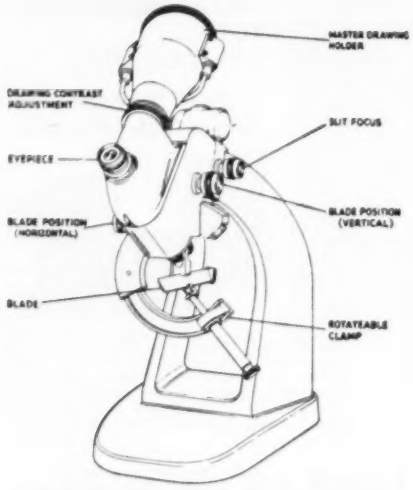
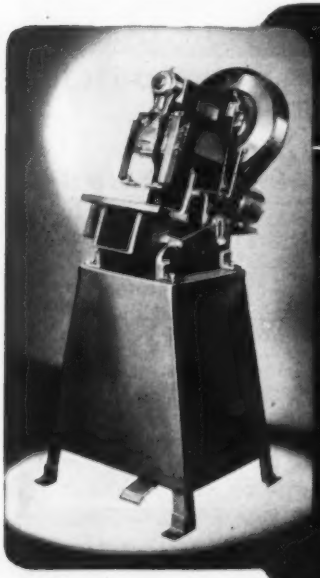


TAYLOR-HOBSON BLADE EDGE MICROSCOPE.

At the request of the English jet-engine industry, this special inspection microscope has been developed to check quickly, accurately and simply the leading and trailing edges of jet blades manufactured by Taylor-Hobson.

Height over-all, 26"; width over-all, 12"; depth (front to back), 19". Capacity, blades up to any length and up to 2½" width. Full length of trailing or leading edge can be viewed up to about ⅛" from root or shroud. Blades up to about 8" length are held in a vee support which is spring loaded. Longer blades are to be held against the upper vee by hand. Special adaptors for such blades are available.

Optical Specifications—Magnification 40X, therefore errors of .001" can accurately be determined. Field of view at the blade edge is .18" diameter.



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Throat Depth — 6" Throat Height — 7"
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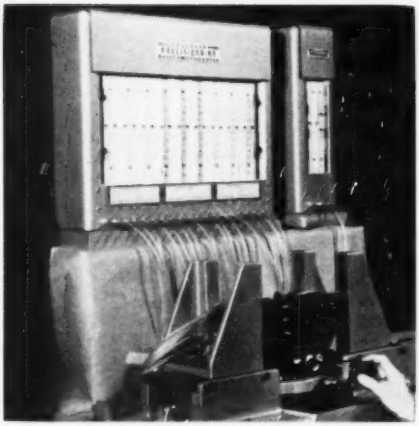
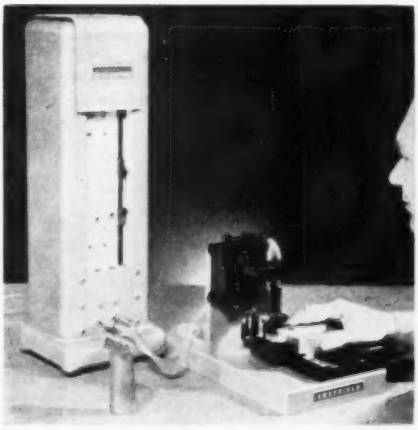
115 FORBES STREET, ROCKFORD, ILL.



18-column Precisionaire fixture inspects for thickness, lean, tilt, twist, centrality and surface contour on a production basis. Once mounted in place, a setting can be made by the use of feeler gages without requiring a master.



First and third serrations on the root form of the dovetail section of jet blades can be checked simultaneously on this development by Sheffield. It is precise but rugged and simple to operate.

WESPO

T-BOLTS

BOLSTER & T-SLOT TYPES
to J. I. C.
press room standards

Forged, precision machined heat treated. Tensile strength 150,000 lbs.

SIZES

BOLSTER BOLTS — dia. to 1½" Heads sq. to 3" hex. to 2⅝" T-Slot bolts, ½", ⅝", ¾" dia. lengths to 12". 1" dia. 4" to 22" long.

NUTS — hardened — threaded to close fit. WASHERS — hardened — ground both sides.

Write for bulletin-prices

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26931 W. 7 Mile Road
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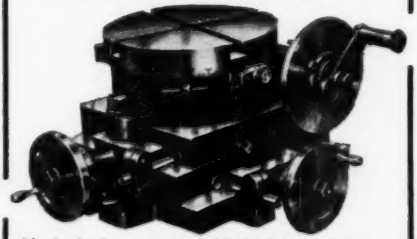
The *STEVENS* Line
SINCE 1925
Showing 7½" Dial Type Rotary Table mounted on compound table No. 1
- Traverse and Circular Movements -



Made in larger size 12" dial type Rotary - compound table No. 2. Either unit usable separately. Five sizes of Rotary Tables. Adjustable tilting tables. Multiple spindle index centers. Screw head slotters. Vises.

Write for Bulletins

The JOHN B. STEVENS Company
SOMERSVILLE, CONN.

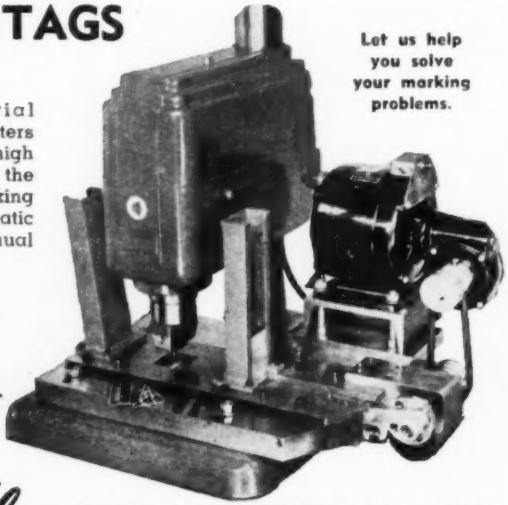
Turbine blades can be 100% inspected for contour, thickness, tilt, and blade angle, at 18 to 26 or more points simultaneously, by a new multiple dimension Precisionaire instrument by Sheffield. Each gage can take the place of up to 11 conventional type gages. Since the instrument was first announced several months ago a number of improvements and refinements have been made; acclaimed for its accuracy as well as for great savings of time and expense.

For measuring large inner and outer dimensions, with a high degree of accuracy, P.I.T. Corp. has developed a special instrument for the jet industry called the Unitest. It consists of a set of adaptors, supports, calibration devices, etc., that result in a very versatile precision instrument that has a range up to 56"—if needed, further extensions of 40" each can be supplied. Temperature changes do not affect it.

MARK 10,000 TAGS PER HOUR

To automatically mark serial numbers and constant characters on name tags at speeds as high as 10,000 per hour use the Automark High Speed Marking Machine. It has three automatic speeds and provision for manual operation.

Just load the hopper and press the starting switch . . . the specially designed slide fixture automatically feeds the tags under the marking head and into the unloading chute for easy removal.



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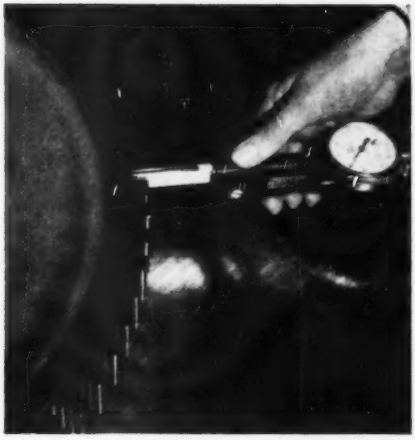
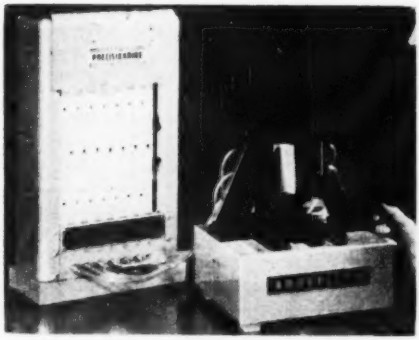


This gage was designed by British Indicators Ltd. for checking fir tree serrations in gas turbine rotors. This instrument operates on the familiar intercheck principle and is actuated by a trigger which controls the measuring cone to expand mandrels of various forms. The mandrel employed for this application consists of two tungsten carbide rollers mounted on spring leaves which are expanded by the cone to measure with fir tree section across its effective width in the serrations.



An air gage assembly that is used to check critical dimensions on a turbine bucket blade simultaneously is a recent development of Sheffield. In one quick step an unskilled operator can check blade taper in relation to root form at three places.

GRAND offers

PRECISION GROUND ARBOR SPACERS

FROM STOCK

HARDENED AND GROUND WITH KEYWAY

Width Inch	7/8 bore 1-3/8 O.D.	1 bore 1-1/2 O.D.	1-1/4 bore 1-3/4 O.D.	1-1/2 bore 2-1/8 O.D.	2 bore 2-3/4 O.D.
1/8	$ .60 ea.	$ .70 ea.	$ .90 ea.	$ .1.0 ea.	$ 1.40 ea.
3/16	.60	.80	1.00	1.20	1.50
1/4	.70	.90	1.10	1.30	1.60
5/16	.80	.90	1.10	1.40	1.70
3/8	.90	1.00	1.20	1.50	1.80
1/2	1.00	1.20	1.40	1.75	2.10
3/4	1.20	1.40	1.60	1.95	2.40
1	1.50	1.80	2.20	2.40	3.10
1-1/4	1.60	1.90	2.30	2.75	3.20
1-1/2	1.70	2.10	2.50	3.20	3.50
2	2.30	2.50	3.00	3.70	4.30
3	3.00	3.50	4.00	4.90	6.70

PRECISION GROUND RUNNING BUSHINGS

FROM STOCK

HARDENED AND GROUND WITH KEYWAY

No. of Bushing	Dia. Bushing Inches	Dia. Hole Inches	Length Inches	Price Each
3-5/8	1/2	1/4	3/4	$7.50
4-5	5/8	5/16	7/8	7.50
4-6	7/8	3/8	7/8	9.00
4-6½	7/8	7/16	7/8	9.00
4-6½	7/8	1/2	7/8	9.00
5-6	1	3/8	1	11.00
5-6½	1	7/16	1	11.00
5-7½	1	1/2	1	11.00

ARBOR SPACER SHIMS

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FOR FAST AND ACCURATE SPACING OF MILLING CUTTERS, GANG SAWS, SLITTERS, ETC.

Each set contains 19 pcs. from .001" to 125".

Diameter of Hole	Outside Diameter	Price per Set
3/8"	1 1/8"	$1.50
1"	1 1/2"	1.50
1 1/4"	1 3/4"	1.50
1 1/2"	2 1/8"	2.20

MICROMETER ADJUSTABLE SPACING COLLARS

FROM STOCK

These collars save milling machine set-up time and eliminate the use of paper shims and thin steel washers. Quick and positive adjustments made without removing cutters from milling machine arbor. Teeth accurately ground and graduated and protected from chips. Standard collars have .002" stop adjustments. When ordering specify size bore only.

Bore Dia. In.	O.D. In.	Collar Thick. In.	Keyway Depth In.	Keyway Width In.	$7.50 each
1	1-7/8	7/16	3/32	1/4	
1-1/4	2-1/8	1/2	1/8	5/16	
1-1/2	2-5/8	9/16	5/32	3/8	

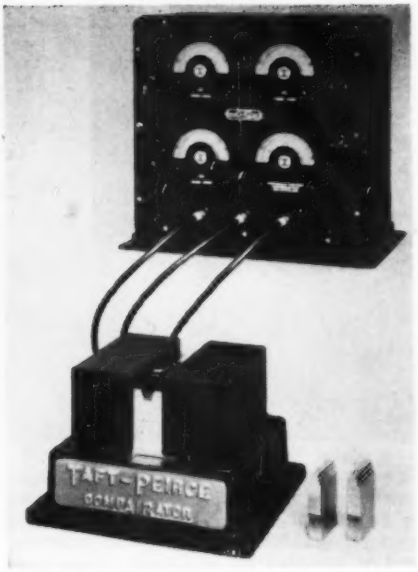
F. O. B. — N. Y. C.

Prices subject to change without notice.

GRAND TOOL & SUPPLY Co.

176-D Grand St., New York 13, N. Y.

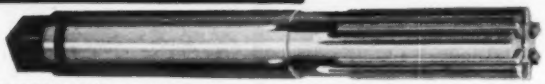
Linear inspection of comparatively large diameter and short length parts can be made without removing the work from machines like right angle or T-lathes. Oversize gage blocks are sometimes employed, such as these made by Webber Gage. Since most of the inspections are critical, the manner of joining these blocks is an important consideration in their design. These blocks are held together with eccentric clamps providing a rigid build-up without excessive pressure. The slight compression of each gage block at either end is offset by counteracting pull on the mid section. Thus the accuracy of ± .000005" is carefully maintained over the entire assembly.



Taft-Peirce recently completed this air-operated gage for measuring the dimensions over rolls of serrations in the root section of turbine blades. The ratio of magnification is 1250 to 1, and three air indicators, with dial graduations of .0001" show dimensions as measured over rolls on each of the three serrated sections. In addition, the new computing indicator has been incorporated as a fourth indicator to compute automatically the difference between the amounts that each of two dimensions varies from its mean value. The company is building two of these air gaging units.

Specify ROGERS

Cut your reaming costs in half with the inserted blade — both adjustable and replaceable.

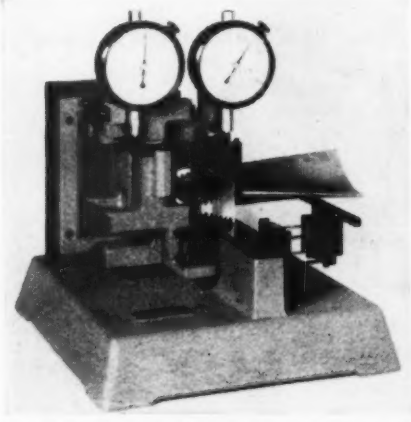


Rogers **ADJUSTABLE BLADE REAMERS** combine low initial cost with **fractional replacement cost** after inserted blades are worn to adjustment limit.

JOHN M. ROGERS TOOL COMPANY

SINCE 1885 GLOUCESTER CITY, N. J.

A recent development of Sheffield is this instrument used to check the width of the first, second, and third convolutions at the fir tree form; squareness and centrality of fir tree form with vee grooves, the dimension from the bottom of the fir tree form to the first convolution, the distance from the bottom of the second convolution to the top of the root form and the lean of the blade to the vees.



Portable Federal bench type gage measures root thickness at two locations of jet engine turbine blade fir tree serrations. Blade rests on reed-suspended support arm while contacts position themselves. Dial indicators show exact root thickness as compared to master setting.

ATLANTIC

SKIP-TOOTH BLADES!

Keep abreast of changing production techniques! A finer, quicker cut on increasingly popular plastic — wood — copper — aluminum — and similar metals is YOURS with versatile Atlantic Skip Tooth Blades. Atlantic's extra wide tooth spacing whisks away chips — ends clogging! binding! heating! The rigid set of individually gauged teeth, the advanced skip tooth design promote increased accuracy and greatly prolonged blade life. Heat hardened teeth on special steel body eliminate most costly blade breakage, damaging crystallization. Whatever your blade requirements are — or may be — investigate the Atlantic Skip Tooth — another triumph of Atlantic adaptability and efficiency.

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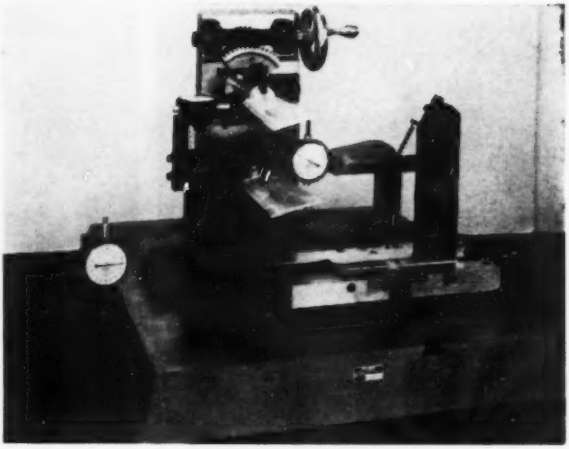
Atlantic

ATLANTIC SAW MFG. COMPANY, Inc.
Brewery St., New Haven, Conn.

This gage checks (1) overall contours and (2) radius from centerline to edge of turbine blade by comparing workpiece with master mounted below it.

The gage is first set up using dial indicator assembly at left. As black handle is turned, bottom contact on pantograph-mounted C-frame follows contour of master blade in fixture while dial indicator above shows contour variation between master and workpiece. Note contour checking unit is mounted on precision ground dovetail slide which can be positioned relative to length of blade. Top crank rotates blade for radius check using master blade as reference position. Manufactured by Federal Products.



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800 LBS. CAP.

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$357.00
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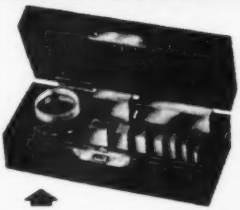
2000 LBS. CAP.

ULTRA-CHEX GAGE BLOCKS *for Every Need!*



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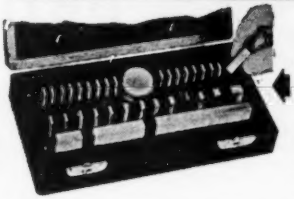

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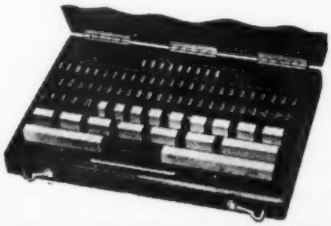
INCLUDING OPTICAL PARALLEL

All Sets at "Money Saving Prices" due to Mass Production Methods.

9 Block Set $22.50
OPTICAL PARALLEL **$5.00**



82 Block Set
$275.00 Complete

This Set will supply the needs of any discriminating shop that must work to gage-block precision.

Dealers: Here's a real profitable line!

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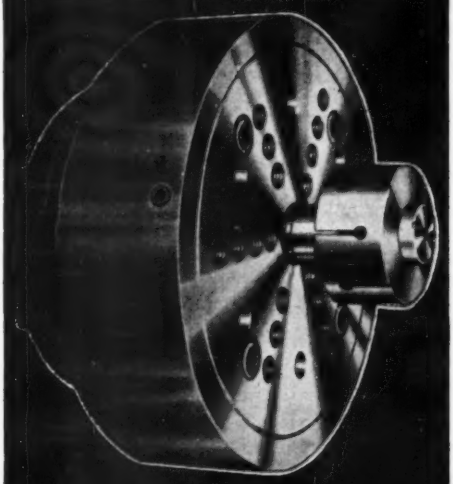
GEORGE SCHERR CO., Inc.

200-MT LAFAYETTE ST. • N.Y. 12, N.Y.



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6. Maintenance cost is low.
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Speedgrip Precision Internal Chucks will save you money on second operation work.

WRITE FOR FREE MANUAL

SPEEDGRIP CHUCK

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REHNBERG-JACOBSON DRILL UNITS

Self-contained Drill Units are fully-automatic and cam-operated for positive quill action. They come in five sizes with drill capacities ranging from 3/16" to 1-1/2" (in mild steel).

These units are all available for *quick delivery.* You can mount them on structures of your own to make practical and efficient production machine tools.

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REHNBERG-JACOBSON MFG. COMPANY

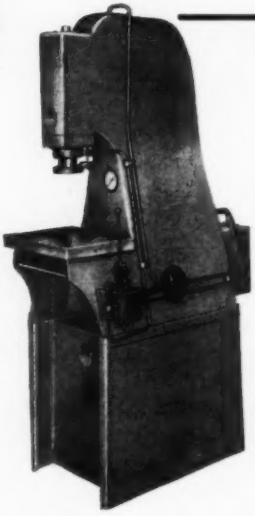
DESIGNERS & BUILDERS OF SPECIAL MACHINERY

R-J

2135 KISHWAUKEE ST.
ROCKFORD, ILLINOIS

NORTHERN

PROVEN POWER—HEAVY DUTY HYDRAULIC PRESSES AT VERY LOW COST



Tough jobs throughout industry are using these presses on production lines in a very wide capacity. As well as, various short run jobs.

Shown is the Model GD which can be had in 10 or 20 ton capacity with strokes up to 24". Models AD or Arch-type frames can be had in 10-20 or 35 tons, also with strokes up to 24".

These presses are all double acting with power both ways.

Presses shipped ready to operate, just make electrical connection.

Write for literature

NORTHERN TOOL and MACHINE CO.

1549 North 31st Avenue, Melrose Park, Illinois

Recent Developments in Miscellaneous Devices, Machines for Jet Industry

The problem of providing a surface finish of 20 micro-inches and better on the tooth surfaces of a serrated tooth face-type coupling on a jet engine compressor rotor front end shaft has been solved by the installation of a special Red Ring grinding machine made by National Broach.

The machine, basically a Red Ring Model SGD spur gear grinder, is adapted to this special grinding application by a special index fixture that holds the part in a vertical position, and by controls that give an automatic grinding cycle.

The rotor shaft serrations are first precision broached on a vertical broaching machine equipped with a special index fixture. Then the rotors are mounted in the special grinder where the serrations are ground to provide the desired surface finish.

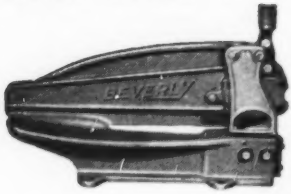
The rotors are manually clamped in the serration grinder fixture by a large socket screw in the center of the top face of the fixture. This fixture is designed to hold the rotor at a slight angle to the vertical centerline, thus enabling the V-shaped grinding wheel to pass through a serration in a straight path. A hydraulic cylinder controlled ratchet mechanism indexes the fixture.

After the part is clamped in the fixture and the grinding wheel set to correct depth by a handwheel control, an automatic grinding cycle is initiated by a pushbutton control. The table passes the part back and forth on a short stroke under the grinding wheel, indexes the part to the next serration space and so on until the 120 serrations are ground and the machine stops automatically. Three such grinding cycles are utilized to provide the desired surface finish. A total grinding wheel vertical feed of 0.005" is made during the grinding operation.

A hydraulically controlled wheel dresser utilizing a master template is mounted on the grinding machine table at the right of the fixture.

Save Time . . . Labor . . . Materials with

BEVERLY metal cutting SHEARS

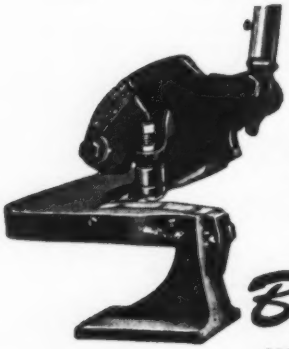


Inside SLOTTER

Makes cuts up to 8" inside edge of sheet. Sharp, clean burr-free cuts always assured. Cap. 16 ga. High strength aluminum alloy body; H.C.H.C. blades.

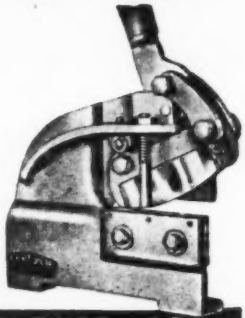
Throatless SHEAR

Make any cut—straight, irregular, curved. Exclusive design permits turning work any direction while cutting. 4 models—cap. to 3/16".



Slitting SHEAR

New "SS" Series—easier cutting with compounded linkage. 3 models — cap. to 3/16"; trimming capacity to 5/16" mild.

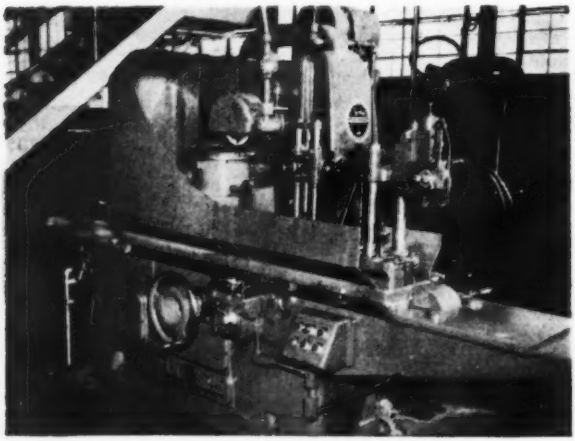


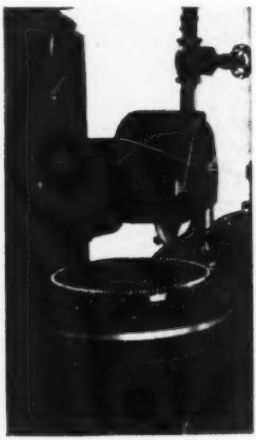
See your Beverly Distributor.
Write for FREE illustrated Bulletin.

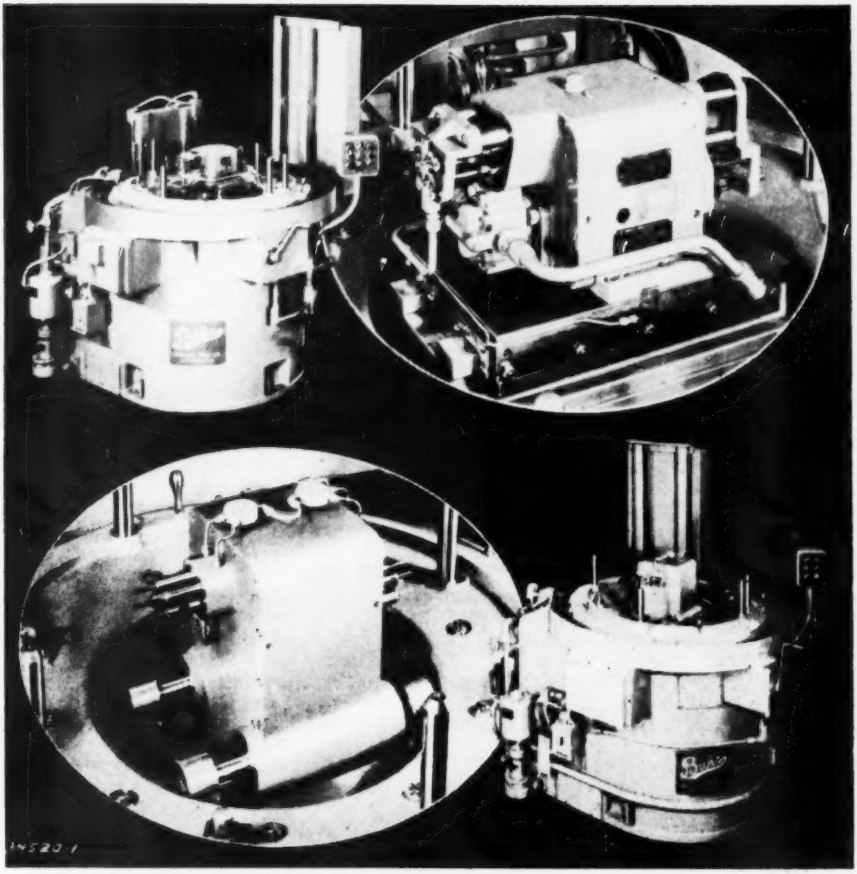
Beverly SHEAR MFG. CO.

3005 W. 111th STREET • CHICAGO 43, ILLINOIS

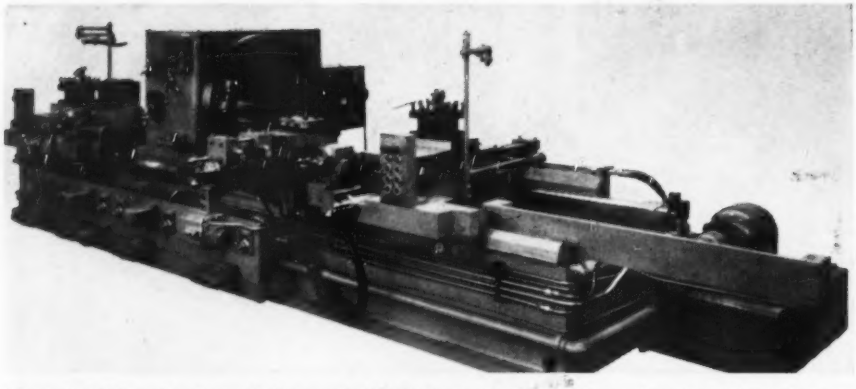
This Red Ring special gear grinder provides a 20-micro-in. surface finish on the serrations of a face-type coupling of a jet engine compressor rotor front end shaft. The rotor is mounted on the table of the grinder, left, with its axis in a vertical position. A hydraulically controlled wheel dresser is at the right of the fixture. The close-up view shows the hydraulic cylinder controlled work holding fixture in position on the grinding machine table. The fixture is indexed automatically during the grinding cycle by a ratchet index mechanism.



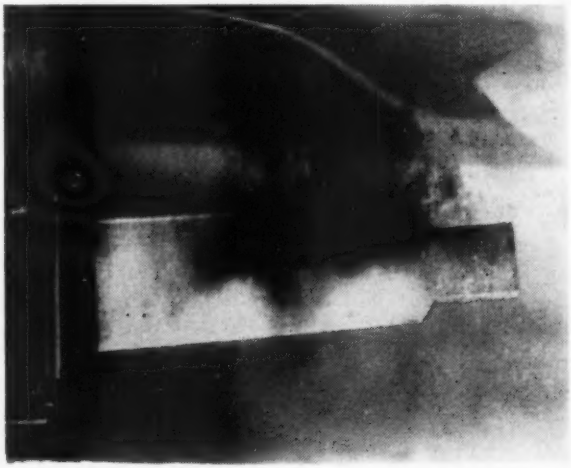




How to drill and tap 24 blind holes (all unevenly spaced and at different levels) on the inside of a jet-engine bearing support and in a working area too small to use a conventional-type drilling unit—this was the problem. A reciprocating-type drillhead mounted on a hydraulically-operated way-type slide, with four drill spindles at each end, solved the problem. Since there wasn't enough room for mounting an electric motor to furnish the power, the drills are driven by a hydraulic motor. By using this method, they also eliminated the need of a change-gear box. Each machine is also equipped with a special rotary table which features irregular spacing. The table is electrically interlocked in such a way that the holes can be drilled only in their proper relative positions. The tapping machine (also illustrated) functions on the same principle as the drilling machine, except taps are driven by master lead screw. These specials were developed by Buhr Machine Tool Co.

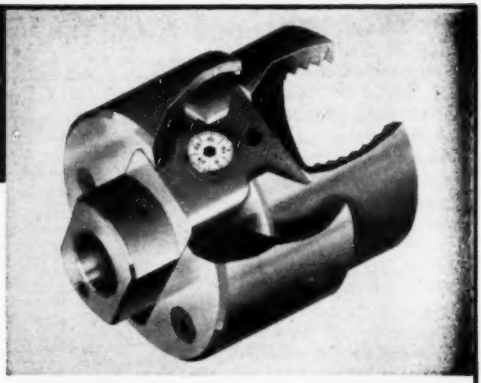


A special 42" swing large hollow spindle Hydratrol lathe has been developed by Lehmann for machining turbine frame assemblies. This machine, at one setting, turns, bores and faces all such machined surfaces, maintaining dimensional accuracy and relative concentricities and squareness of surfaces difficult to secure when the workpiece has to be reset. The hole in the spindle and chucks is 18" and face to face of the chucks is 30½". Due to the flexibility of the workpiece special chucks are provided and segmented bracelets surround the gripping surfaces to avoid distortion in chucking. Hydraulic longitudinal feeds with automatic stops are provided for all dimensional requirements. A total of 16 surfaces are machined, 8 facing, 5 turning, and 3 boring. Hand valve control provides rapid traverse to all slides. Coolant & chips are disposed to a pan in the rear in which the chips are held in the top section and the coolant flows to the lower section. The bed of the machine, 16 feet long, is 42" wide with hardened steel ways. There are 6 spindle speeds from 21 to 100 rpm and 20 h.p. motor driving the hydraulic friction clutches on the pulley shaft. Complete machine weighs 30,000 lbs.



Foreign matter adhering to the surface of a jet engine blade is shown here as it is almost literally "exploded" away by ultrasonic waves. In this case, the substance is an iron oxide paste which is used to coat the blades to help detect possible flaws and which is extremely difficult to remove by ordinary methods. The element projecting the sound waves in this photo is part of a new ultrasonic process for industrial cleaning developed by the Detrex Corp. of Detroit.

SAMSON
Offset
BORING CHUCKS



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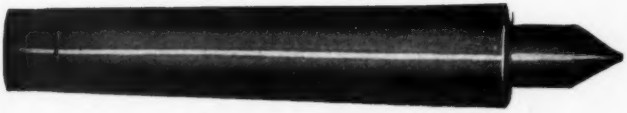

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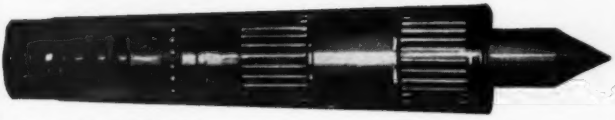

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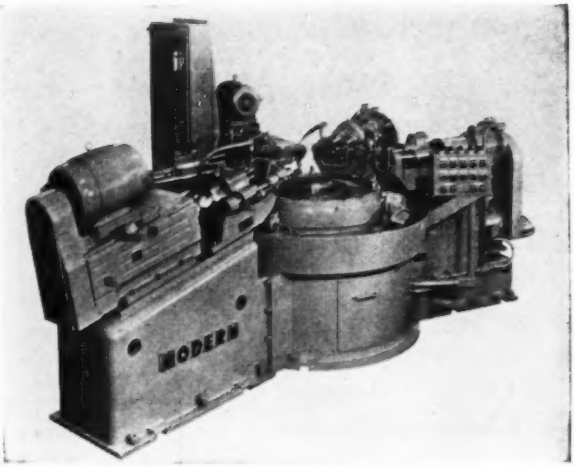

This 5-way drilling machine for housings features interchangeable multiple drill heads on two of the five stations which enables the production of several types of housings having a variety of bolt circle specifications on faces with identical radial locations. Loading, clamping and indexing of the housings in the fixture are done manually to meet the requirements of producing a precise part in relatively low production with minimum scrap. It is made by Modern Industrial Eng. Co.

Metal cleaning by ultrasonic waves, known as the Detrex Soniclean process, features a man-made element for directing sound energy—a development which Detrex technicians say opens the door to far-reaching advances in a wide variety of industrial fields.

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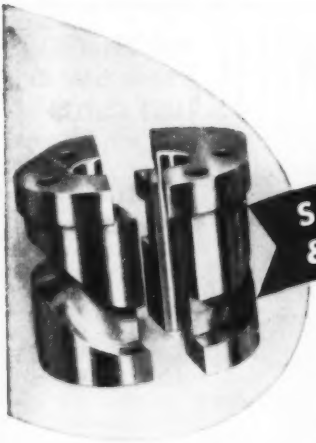

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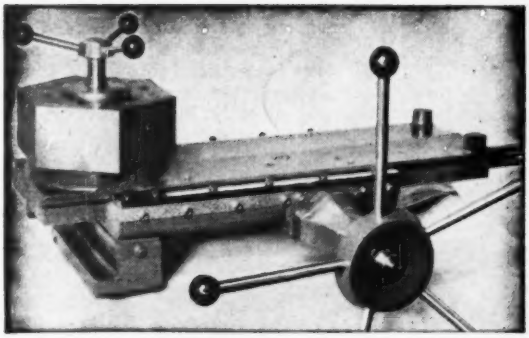

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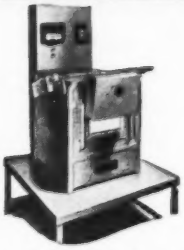

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Operations on rotor compressor wheels are carried out by three special Barnesdrill Unitype machines developed for three separate manufacturers. The one shown is a special vertical four station rotary production unit consisting of one U-2375 hydraulic unit which is equipped with a 52 spindle fixed center auxiliary head and one U-2045 unit equipped with a 26 spindle fixed center auxiliary head. Each unit is equipped for rapid approach, feed and rapid return. It also has a four station, 75" diameter hydraulic rotary indexing table with chip sweeper.

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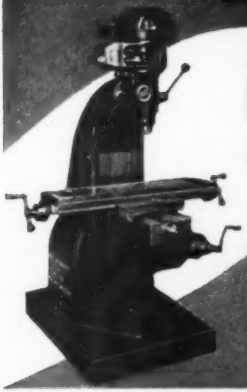

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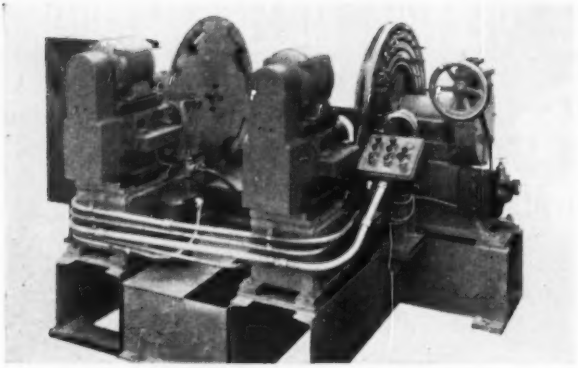
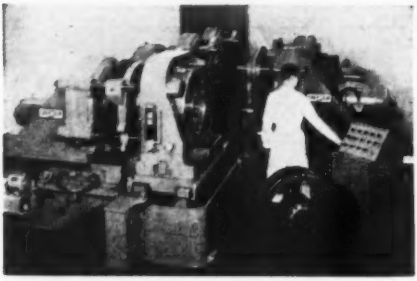
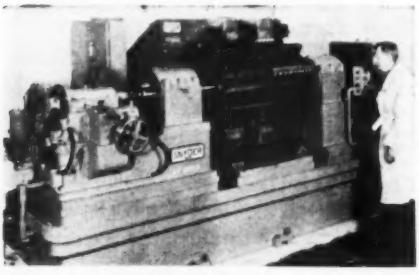


Designed and built for milling the inside flange faces on jet housings, this special machine is manufactured by Pioneer Tool & Eng. Co. Automatic air cylinders are used for clamping the housing against holding faces and each milling head automatically oscillates in and out six times within the machining process, to clear outside ribs.

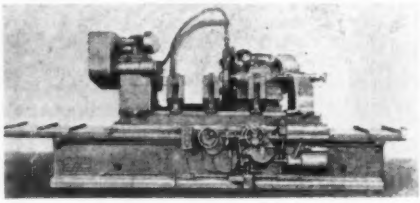


A four-station line index machine for drilling, chamfering and line reaming the front main bearing support; operations are performed on both sides of the part as it progresses through the machine; made by Snyder Tool & Eng. Co.

Designed for the great variety of grinding operations required in the production of jet engines, this Norton machine combines universal features; massive construction throughout insures stability. The sliding table is hand operated for setup work and hydraulically powered for traverse grinding operations or setup work. A swivel table permits taper grinding. A compound type wheel slide provides for grinding from 0" to 42" diameter workpieces with full size 30" diameter grinding wheel. This wheel slide swivels 180° under power, permitting rapid angular settings. Provision is made for those operations requiring internal grinding or facing with small wheels. An auxiliary spindle can be mounted on the back of the wheel slide permitting the grinding of those surfaces which cannot be ground with the standard wheel.



Snyder special hydraulic feed grooving machine. This machine grooves the turbine blade mounting slot in the compressor housing. It grooves all 13 slots in one half of the housing at a time.



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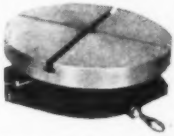

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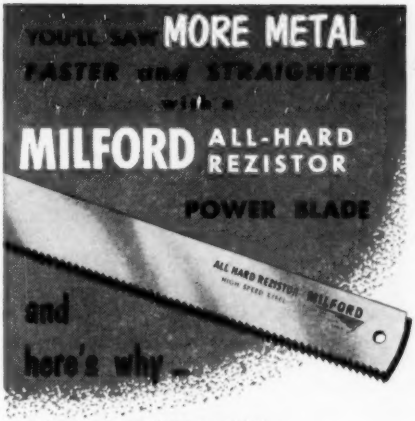

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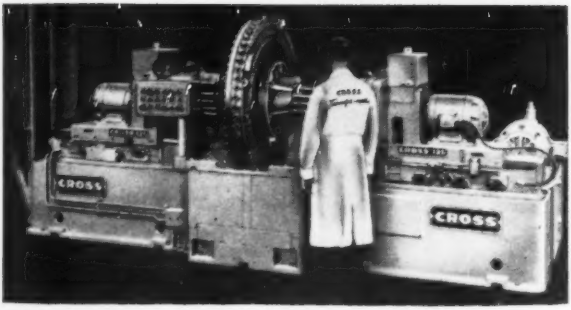

Small photo shows the operator inserting steel blades in a special Cross fixture prior to drilling rivet holes in the outside diameter of the discs which hold the blades in position. After assembly, the fixture is positioned in the special Cross machine which drills and reams the rivet holes.

This new unit built expressly for rolling and forming of cones and conical frustums used in the jet engine program is made by Reed Eng. Co. It employs three conical-shaped rolls mounted in a cantilever design; each roll is driven by separate motor, and is also adjusted independently. The rolls can be set from full parallel up to a 45° included angle. Forming rolls are interchangeable.

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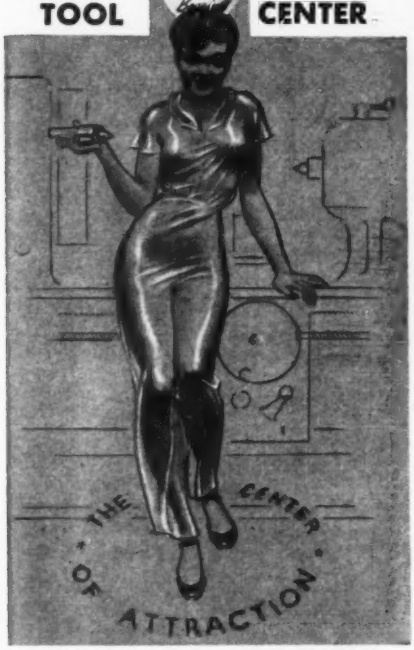

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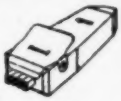

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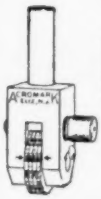

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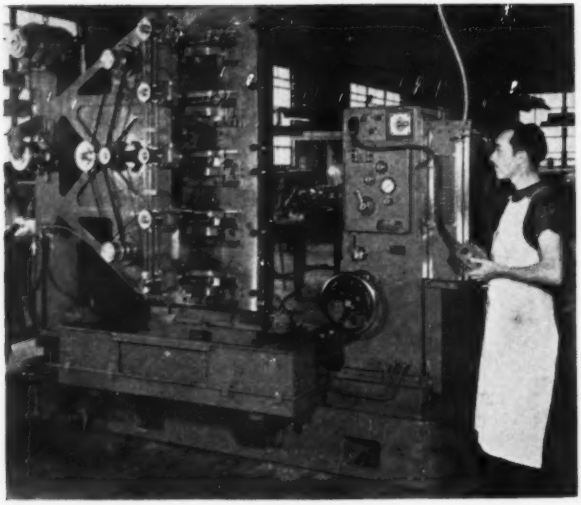
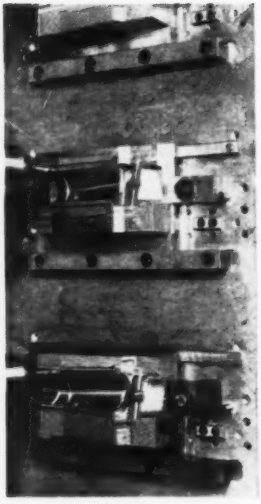
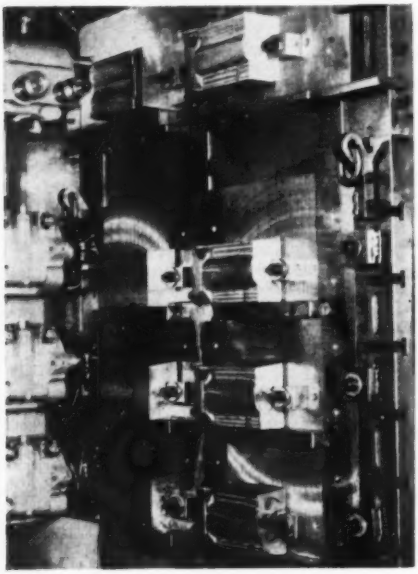




The four-spindle Pratt & Whitney automatic duplicating machine is finish machining a set of four female die halves for a deeply curved turbine bucket. Hand polishing is needed only to remove mill marks; no hand correction of airfoil shape is required. Average machining time is just over 30 minutes per die half. Dies are often unavoidably distorted in hardening to the usual Rockwell "C" 60-63. Since carbide burrs are used in this machine, these dies can easily be replaced in the automatic duplicator and recut, if necessary.



Roughing die blocks with the Pratt & Whitney Keller machine; this Type BL-3620, three spindle machine is performing the roughing operation on three male die halves at once; the female halves are similarly handled; average machining time is about 30 minutes per die half.

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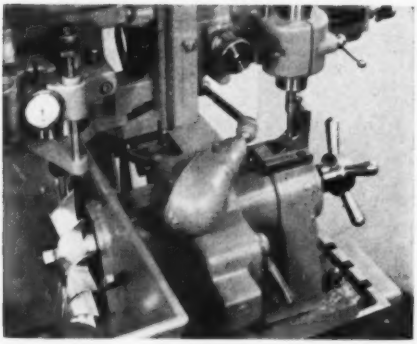
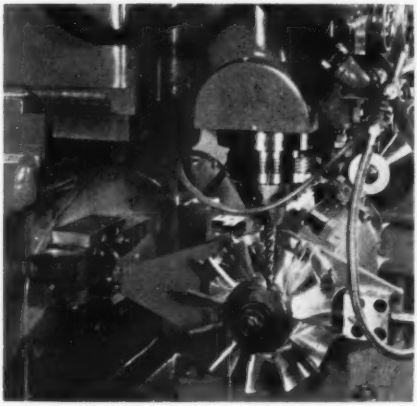
Hydraulic grinder of Cincinnati Milling specially arranged to swing 29 inches for grinding rotor shafts. The sliding table of the machine is widened and the swivel table is both widened and raised so that it can be properly relieved. There is also a raised wheelhead, with a built-in automatic wheel balancing mechanism. A profile hydraulic truing device is mounted behind the grinding wheel, providing an accurate means of truing the form.



Cincinnati 8" x 18" tool and die miller specially arranged for profile milling excess stock from the hub section between impeller blades. The automatic depth control tracing unit with tracer finger and template controls the vertical movement of the spindle carrier. The automatic depth control duplicates the hub contour while the table feeds longitudinally. At the same time, a varying degree of oscillation is imparted to the workpiece so that the entire hub section between blades is milled. This oscillation is accomplished by the use of a special hydraulic tracer contacting a closed contour cam. As one side of the cam contacts the tracer, a hydraulic cylinder is actuated which reverses the direction of reciprocation.



Two-spindle vertical Cincinnati Hydro-Tel mills the profile around inducer impeller blades. The machine is equipped with an automatic depth control attachment with tracer finger following a template mounted on a special fixture to control the hub form and diameter. The machine is also equipped with a 360 degree selective automatic tracing unit to form the impeller blades. While the table feeds longitudinally, the workpiece is caused to rotate by cams fixed to the machine base, thereby holding the correct relation between the centerline of the blade and the center of the impeller wheel.

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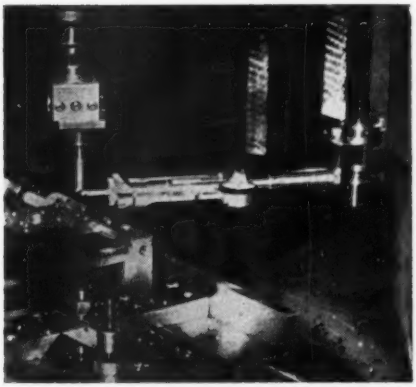

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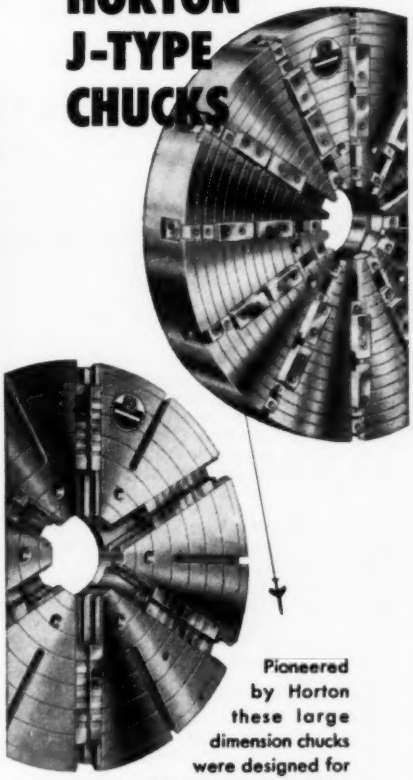

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AVAILABLE LITERATURE

FREE CATALOGS AND BULLETINS AVAILABLE FROM MANUFACTURERS

For copies of the literature in which you have an interest, use the postage-paid postcard on the next page. Merely circle the identifying numbers and mail the postcard.

1. Automatic Controls. Controls for domestic heating applications, for industrial applications, and magnetic and motorized valves are covered in Catalog No. 700-B, the Mercoid Corp., 4201-BB Belmont Ave., Chicago 41, Ill. Controls are equipped with sealed Mercoid mercury switches.

2. Deep Drawn Boxes, product of Zero Mfg. Co., 1121-B Chestnut St., Burbank, Calif., are listed in Catalog No. 4. Aluminum boxes are said to be held to close tolerances both in length and width, and to have a smooth satin finish. Also included are sections on contract manufacturing and metal stampings.

3. Centerless Lapping Machine. Size Control Co., 2500-BB W. Washington Blvd., Chicago 12, Ill., has released a 4-page brochure (L-53) describing their centerless lapping machine. Machine is said to produce finishes of less than 1 microinch rms, and to eliminate ring lapping.

4. Furnace and Induction Brazing. An illustrated case-history technique is used in Bulletin GEA-5889, General Electric Co., News Bureau BB, Schenectady 5, N.Y. Cost reduction, increased production, and higher quality are claimed to be attributes of furnace and induction brazing.

5. Resistance Welders, electronic welder controls, solenoid operated air valves, welding transformers are all covered in bulletins of the Taylor-Winfield Corp., Warren, Ohio. Standard and stocked parts make up the guns with mobile welding units.

6. "Die Steels for Hot Work," a booklet of Vanadium-Alloys Steel Co., Dept. BB, Latrobe, Pa., details the uses, composition and heat treatment of these steels and presents a thorough discussion of their metallurgical characteristics. Also available, "Die Steels for Cold Work."

7. Handbook of electrical, electronic components—ideas, techniques, designs—issued by Alden Products Co., 117-B N. Main St., Brockton, Mass. Gives over-all designs and components to build any electrical or electronic equipment using plug-in unit construction.

8. Tungsten Carbide Tool Tips, Dies, Wear Parts. The Adamas Carbide Corp., Dept. BB, Harrison, N.J., has published new catalogs and price lists. Recently the company added a line of standard carbide tools, which is also covered by catalog.

9. Abrasive Cutting is subject of Catalog No. 1 (revised), the Allison Co., Dept. B, Bridgeport, Conn. Treats wet, dry and submerged cutting. General recommendations for the selection of abrasive wheels are given.

10. Metallurgy and Ceramics. Bulletin TID-3050 (part 1), Industrial Information Branch, United States Atomic Energy Commission, Washington 25, D.C., is a bibliography of selected reports on technological developments in the atomic energy program.

11. Shop Tools, Socket Sets. New pocket-size folders, one cataloging its line of shop tools, and the other describing its line of socket wrench sets, have been issued by

the Billings & Spencer Co., 1-BB Laurel St., Hartford, Conn. Shop tools listed include C clamps, strap clamps, machinists' clamps, chain pipe vises, hoist hooks, crank handles, ball peen hammers, and a line of screwdrivers.

12. Four-Point Tooling and Manufacturing Service—design and development, precision tooling and jig boring, custom-built machines, precision parts—is covered in bulletin of Bloomfield Tool Corp., Dept. BB, 34 Farrand St., Bloomfield, N.J.

13. Flanging Machines. A. S. M. E. code heads up to 8' dia., manufactured by Blue Valley Machine & Mfg. Co., 6832 Truman Rd., Kansas City 3, Mo., are illustrated and described in brochure issued by the company. Included are machines for pressure vessels and storage tanks; for all kinds of tanks; for all types of flat heads; elliptical head flanging machine.

14. Drilling Machines. No. 22, product of Buffalo Forge Co., Dept. BB, Buffalo, N.Y., are covered in Bulletin No. 2989-G. Round column or pedestal types, sensitive or power feed, single and multiple spindles.

15. Sectional Stock Racks. A new folder (Bulletin 26-S) on sectional arm racks, issued by the Brown Eng. Co., Dept. B, 132 N. Third St., Reading, Pa., shows how to save storage space and yet retain easy access to a variety of sizes and shapes of bars, rods, strip, tubing, pipe, conduit, shafting, and other types of metalworking stock.

16. Cemented Carbide. Latest information on the use of cemented carbides in wear-proofing pulverizing equipment is available in pulverizing bulletin (WR-107) issued by Carboloy Dept. BB, General Electric Co., Detroit 32, Mich. Applications range from processing alfafa to pulverizing powdered metal.

17. "Facts About Silicon Carbide" is a 52-page brochure of the Carborundum Co., Dept. BB, Niagara Falls, N.Y. Properties, applications, and manufacturing techniques are included. Silicon carbide is finding increasing use in the manufacture of super-refractories and refractory cements, electric heating elements, resistors, catalyst carriers, porous media.

18. Industrial Training. Officials charged with apprentice training in industry will be interested in Bulletin 5329, South Bend Lathe. Dept. BB, South Bend 22, Ind., which covers their standard books on lathe, drill press and shaper operations; charts and shop course book, and audio-visuals. Films, slides, scale models are on a free-loan basis.

19. A Honing Chip for precision barrel finishing, Novaculite is a natural abrasive, more commonly known as hard Arkansas stone. Brochure of Chicago Wheel & Mfg. Co., Dept. B, 1101 W. Monroe St., Chicago 7, Ill., explains features of product, which is being introduced in the form of sized chips.

20. Bearings, Machine Parts, oil-cushioned self-lubricating, manufactured by the Chrysler Corp., Amplex Div., Dept. BB, Detroit 31, Mich., and called "Oilite," are described in new bulletin. Oilite Bronze is for use wherever bronze is applicable; Super-Oilite fits in where bearing loads are in excess of 10,000 p.s.i., particularly at low velocities; Iron Oilite is especially suited to chemical and electrical requirements.

21. Power Control Unit, Milling Attachments. Bulletins issued by the Cincinnati Milling Machine Co., Dept. BB, Cincinnati 9, Ohio, include one dealing with their Flamatic power control unit for selective heating operations like these: spot harden, spin harden, progressive harden, combination harden, braze. Publication No. M-1816 covers the heavy duty universal spiral milling attachment. Bulletin No. M-1766 illustrates the heavy duty vertical milling attachment.

22. Broaching Machines, Services. Pictures, descriptions and specifications for each of their 12 basic types of machines are provided in Bulletin No. 877, released by the Colonial Broach Co., P. O. Box 37, Dept. BB, Harper Station, Detroit 13, Mich. Also described are the broaching services of this firm.

23. Toolmakers' Flat, made from Microflat black granite, is detailed in brochure from Collins Microflat Co., 2326-B E. 8th St., Los Angeles 21, Calif. Flat is precision-ground to .0002" over-all accuracy; nonglaring; temperature-inert; resistant to nicking.

24. Mounted Points and Wheels. Radiac mounted points and mounted wheels, A. P. de Sanno & Son, Inc., Dept. BB, Phoenixville, Pa., are for grinding any material—steel, iron, brass, bronze, aluminum, all alloys, all plastics, porcelain, glass, wood. Catalog 104 available from manufacturer.

THIS HELPFUL LITERATURE NOW AVAILABLE

25. Tap Sizes, Thread Forms pertaining to Standard Specific taps are contained in Bulletin ST-53 issued by Detroit Tap and Tool Co., 8615-B E. 8 Mile Rd., Base Line, Mich. Taps are listed for steel and tough materials, cast iron, aluminum, zinc die cast metals, brass, and plastic and bakelite.

26. Hitch Feed. A factual bulletin on the Dickerman 2½" Model K hitch feed has been issued by the H. E. Dickerman Mfg. Co., 321-BB Albany St., Springfield, Mass. Ten additional catalogs and bulletins on die feeds, hitch feeds and other products of the company will also be sent to those requesting the new bulletin.

27. Micrometers. The DoAll Co., Dept. BB, Des Plaines, Ill., distributor for the Tumico line of precision measuring instruments, announces the availability of a catalog covering this line. Gives full details on the tubular micrometer series, with the tubular, vacuum-sealed frame.

28. Keyway Broaches. The du Mont Corp., Dept. B, Greenfield, Mass., offers a catalog designed for quick reference on the complete range of Minute Man keyway broaches and sets, including combination sets, push-type production broaches, arbor presses, magnetic bases, and special broaches.

29. Furnaces, Line Burners, products of Eclipse Fuel Eng. Co., Dept. MB, Rockford, Ill., are contained in two bulletins. Among items illustrated in Bulletin D are tank heaters, and air draw, salt pot, metal melting, large oven, small shop, and forging furnaces. Bulletin H-17 includes description of line burners and examples of typical line burner arrangements.

30. Stop Nuts. Applications of Elastic stop nuts, Elastic Stop Nut Corp., Dept. B, 2330 Vauxhall Rd., Union, N.J., are illustrated in Bulletin No. 250. Feature is red elastic collar — fibre or nylon— crimped into the nut to form a one-piece self-locking fastener which hugs bolt or stud threads, damps out vibration, can't shake lose.

31. Plastic Comparator Charts. Catalog-price list No. 53-70, Gage Co., Dept. BB, Battle Creek, Mich., gives information on standard precision plastic comparator charts and projector accessories, for use on all makes and models optical comparators and projectors. Included are radii charts; protractor with 5′ vernier disc, for all comparators not equipped with screen rotation; measuring charts; comparator scales, etc.

32. Honing Machines, for precision finishing of internal cylinders. A detailed explanation of the process of honing, correction of geometrical inaccuracies are contained in 15-page booklet of the C. Allen Fulmer Co., 1211-B First National Bank Building, Cincinnati 2, Ohio. Also included are applications, types of honing machines.

33. One-Piece Blind Rivet with Threads. Rivnuts, product of the B. F. Goodrich Co., Dept. BB, Akron, Ohio, are upset with a heading tool that transmits a pull on the threaded portion so that the counterbore has to give. A bulge starts to form and the threads push the counterbored portion until the expanding metal seats itself firmly against the material being fastened. The pull-up stud on the heading tool is removed, and the installation is complete. Data book gives full details.

34. Small Hole Drilling Machine. Bulletin V-53, Hamilton Tool Co., 826 S. Ninth St., Hamilton, Ohio, contains information on the Varimatic super sensitive, variable speed, small hole drilling machine. Speed adjustment is variable in two speed ranges, from 840 r.p.m. to 9300 r.p.m.

35. Precision Lathe. The 2E specification sheet, Hendey Machine Co., Inc., Dept. BB, Torrington, Conn., gives details and specifications covering the No. 2E 14" general purpose precision lathe with electronic motor control recently announced by the company.

36. Tools and Accessories for Paving Breakers are listed in Bulletin 4126 of Ingersoll-Rand Co., RD, 11-B Broadway, New York 4. The various units of the paving breaker line are given with illustrations and specifications. Each tool or accessory is illustrated and its recommended applications listed. Instructions for reforging and rehardening moil points, chisels, wedgepoint, etc., are also given.

37. Jig & Fixture Components. A folder describing an expanded line of jig and fixture components is announced by the Jergens Tool Specialty Co., Dept. B, 712 E. 163rd St., Cleveland, Ohio. Items il-

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lustrated include blank jaws, sine fixture keys, malleable handles, tee slot nuts and bolts, shoulder and thumb screws, hand wheels, rest buttons, quarter turn screws.

38. Wax Products. Bulletins issued by S. C. Johnson & Son, Inc., Dept. BB, Racine, Wis., include the following: "Stik-Wax," for metal working; "Forming Metal," with Johnson's wax drawing lubricants; "Metalworking Case Histories," using Johnson's wax lubricants; "Cutting Metal," with Johnson's wax cutting fluids.

39. Chip Breaking. Publication of a research report on chip breaking, consisting of a study of three-dimensional chip flow, is announced by Jones & Lamson Machine Co., Dept. B, Springfield, Vermont. Findings are primarily applicable to turning operations. A wall chart gives directions on the optimum shape of the tool, including angles of rake and clearance and the dimensions of the chip breaker.

40. Special Machine Tools. A new booklet, "Doorway to a Proven Method for Solving Big and Small Metalworking Problems," by the Kearney & Trecker Corp., Dept. B, 6784 W. National Ave., Milwaukee 14, Wis., is designed to provide solutions to metalworking problems. Features story of the firm's new special machinery division.

41. Cemented Carbides. Bulletins available from Kennametal Inc., Dept. BB, Latrobe, Pa., deal with the following subjects: cemented carbides; reduction of tool maintenance costs; tungsten carbide dies; Kentanium, heat-resistant titanium alloy; tungsten and titanium carbides.

42. "Metal Stampings," Kickhaefer Mfg. Co., 901-BB, S. 2nd St., Milwaukee 4, Wis., is a book of engineering drawings and specifications for metal stampings. A wide variety of parts is shown: tubing and wiring clamps, pipe clamps, expansion plugs, core hole plugs, retainers, special lockwasher, horseshoe washers, valve spring washers, etc.

43. Vibration. How to isolate vibration on a cushion of Armstrong's Vibracork, a resilient board made of pure granules of cork, is described in Bulletin VC-501, available from the Korfund Co., 48-39W 32nd Place, Long Island City 1, N. Y. Deflection curves, physical properties, and methods of installation, with typical drawings, are included in the bulletin.

44. Clamps, Pliers, Wrenches. Illustrations of the complete line of Knu-Vise products, Lapeer Mfg. Co., Dept. BB, 3056

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Davison Rd., Lapeer, Mich., are included in Catalog R-12. Jumbo clamps provide for pressure spindle adjustment along the toggle bar.

45. Grinders. Catalog in loose-leaf style issued by the K. O. Lee Co., Dept. BB, Aberdeen, So. Dakota, illustrates and describes the company's complete line of grinders. Included are tool and cutter, chip breaker, carbide tool and universal grinders.

46. Universal Drilling and Tapping Machine. Brochure of Magna Engineering Corp., Dept. MB, Menlo Park, Calif., includes information on drill heads, power feed, columns and bases, magnetic starter assembly, etc., of the Magna drill. Can drill or tap holes in more than one plane at the same time.

47. Tool Block, Tool Holders. Four-faced tool block and instant change tool holders are described in new 6-page illustrated folder of Marvic, Inc., 350-B Peninsular Ave., San Mateo, Calif. The Lathemaster will accommodate most lathe tools and may be fitted to any engine lathe.

48. Oil Jet Center for lathe and grinding machine, Tool Service, P. O. Box 10265-B, Tampa 9, Fla., is described in new bulletin. Oil Jet features forced internal lubrication, whereby grease is stored in a grease cup and applied to the work through tiny jet in center of center point.

49. Drill Stop. Redesigned drill stop, with non-rotating stop, product of Wohlnip Engineering Co., Dept. BB, 390 Hillside Ave., Hillside, N.J., is subject of bulletin just released. Used for drilling, center drilling, counterboring, countersinking, reaming, end-milling, boring, tapping, engraving.

50. Control Valve. The Valvair Speed King solenoid pilot operated control valve, Valvair Corp., Dept. BB, Akron 11, Ohio, is illustrated in Bulletin SK-53. Speed King is for the control of air or low pressure hydraulic applications. Two basic full pipe orifice area sizes, 3/8", 3/4". Pipe tapping, 1/4", 3/8" and 1/2" for the 3/8" valve; 1/2", 3/4" and 1" for the 3/4" valve.

51. Inclinable Presses. Long slide principle inclinable presses, the V & O Press Co., Dept. BB, Hudson, N.Y., are treated in new booklet. Manufacturer claims long slides and ways give higher precision, since there is less opportunity for the punch or other slide-carried tooling to travel in an untrue path.

52. Magnetic Chucks. The latest edition of Superpower Magnetic Chuck Catalog No. 411, the Taft-Peirce Mfg. Co., Dept. B, Woonsocket, R.I., covers the company's entire line of electromagnetic chucks.

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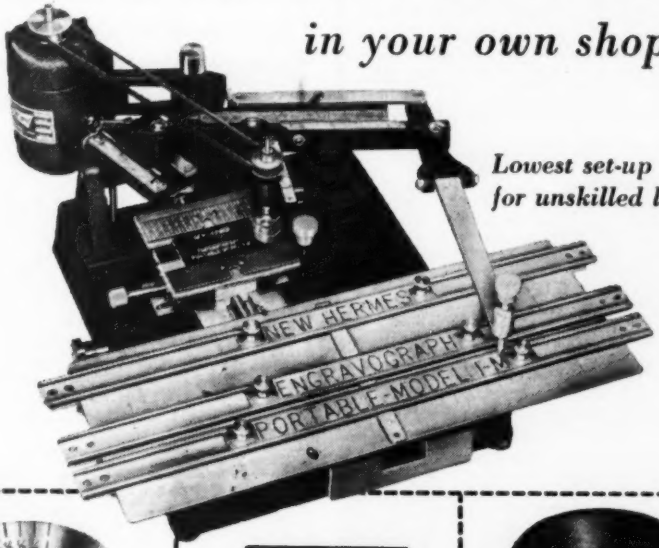

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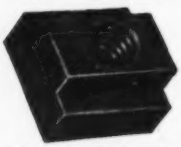

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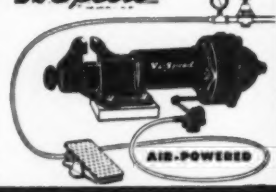

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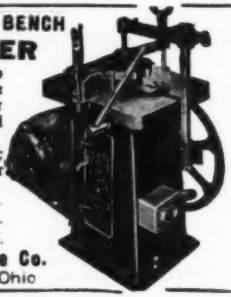

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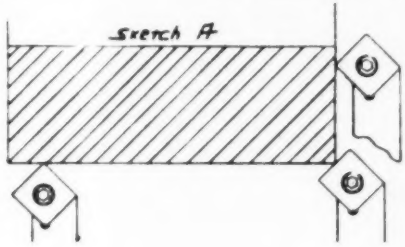
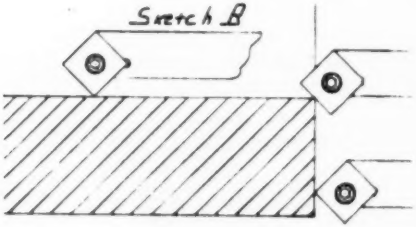


problems were encountered. Major companies came through with their standard tools to meet the demands



for awhile, but as new demands were made, some newer concepts had to be met and newer tools developed. In the search for new metals to withstand thermal shock and high temperatures much of the research resulted in new metals for new cutting tool materials as well.

Practically all jet parts are finished all over. To accomplish this, tools are required for turning, boring, facing, and quite often, chamfering. Since so many cuts are not long dimensionally, the ratio of indexing or tool changing time to actual cutting time is often high.

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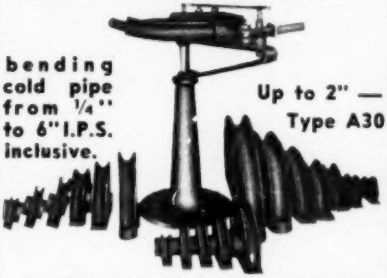

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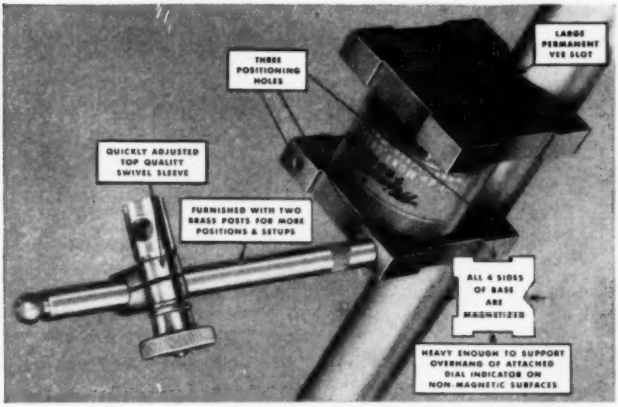
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that these changes will not cause movement of the carbide insert, the tool must be designed to resist forces from all directions. A tool such as this is adaptable to jobs requiring changes in tool geometry. The included angle can be increased or decreased to suit the particular need, and the clearance can be modified if necessary.

As a result of extensive research work, Kennametal developed a series of cemented carbide compositions based on titanium carbide and intended for application at temperature and stress conditions under which alloys and ceramics have not proved satisfactory. Structural alloys—those that can be melted and precision cast, or cast and forged, or otherwise hotworked to shape—are limited in their ability to withstand heavy loads at elevated temperatures. Ceramics retain their strength at high temperatures and are resistant to

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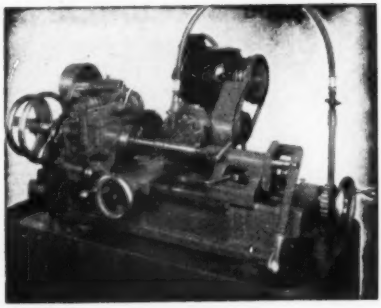

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oxidation, yet, for many applications, they are too brittle and deficient in thermal shock resistance. Kentanium, Kennametal's cemented carbide, has titanium carbide as its chief ingredient, with nickel as the primary auxiliary metal, or other metals as conditions dictate. Most compositions contain a small percentage of other refractory metal carbides, such as tantalum and columbium, which have higher melting points than titanium carbide. A small quantity of these supplementary ingredients is effective in making the compositions highly resistant to oxidation. Many grades have been developed to satisfy the varied requirements of temperature, stress, oxidation resistance, thermal shock resistance, hardness, etc.

It has been stated that power output of jet or gas engines can be tripled by raising the operating temperature 800° above the current level of 1400° to 1500°.

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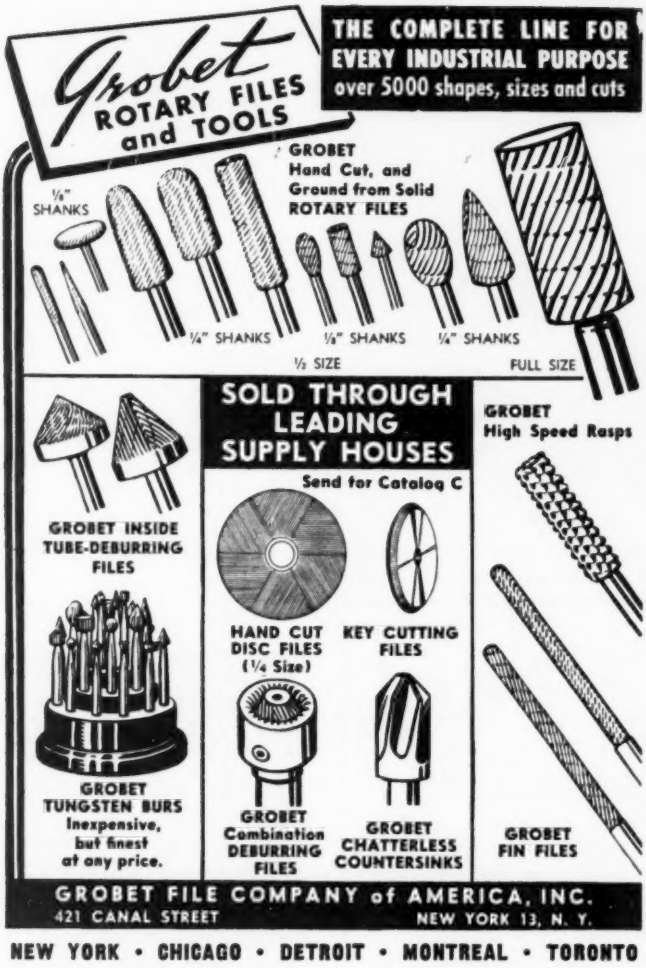
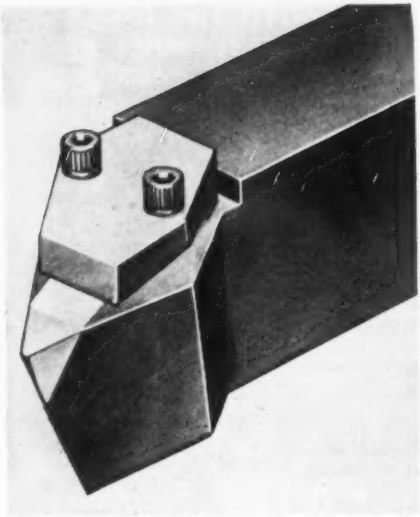
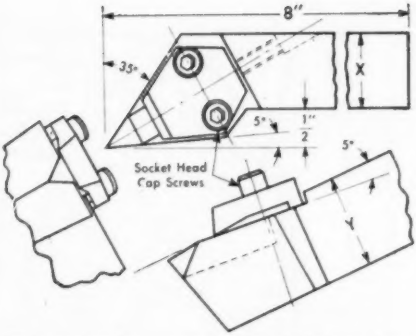


Kentanium permits a big step in this direction if recent extensive laboratory and engine tests are any indication. Some of the tests are being made with such parts as turbine blades and buckets, exhaust valves for reciprocating engines, wastegate valve shafts, turbine nozzle vanes and afterburner segments which present a severe test at 2000 to 2500° F. Other materials will withstand this heat for only about ten hours; it is indicated that Kentanium will exceed this by a considerable margin. Unlike conventional alloys, Kentanium is not melted and cast, but is made by advanced methods of powder metallurgy.





The contouring or profiling tool shown here is adaptable to conventional type tracer lathes or boring mills and particularly T-lathes. The V seat design provides positive resistance against thrust in any direction. Here the insert becomes an almost integral part of the tool. Movement from side thrust in either direction is virtually impossible. The two-screw clamp prevents any tilting or lifting of the insert and the back-up screw resists any axial movement.

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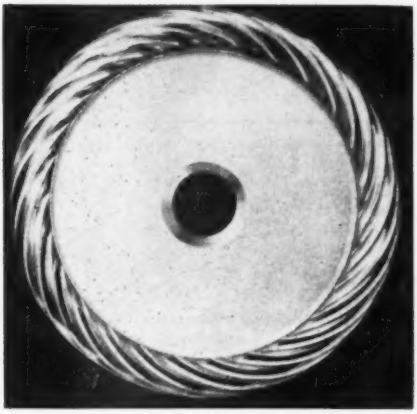
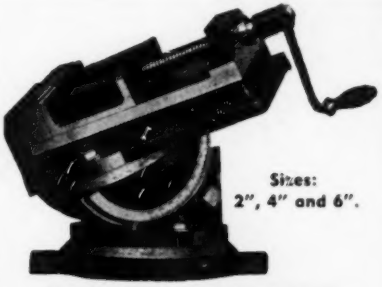
Strength, abrasion-resistance, and oxidation-resistance at high temperatures are requisites in these typical components made of lightweight, heat-resistant Kentanium. Items shown include crucible, nozzle vane, blades for jets, valves, balls for hardness testing, bushings and flame tubes.

Shear type milling cutters with high helix have been developed especially for such applications as the cutting of turbine compressor blades, stator vanes, buckets and generating cams. This one manufactured by Douglas Tool has a cutting surface of more than 90° and is designed to mill compound, contoured surfaces.





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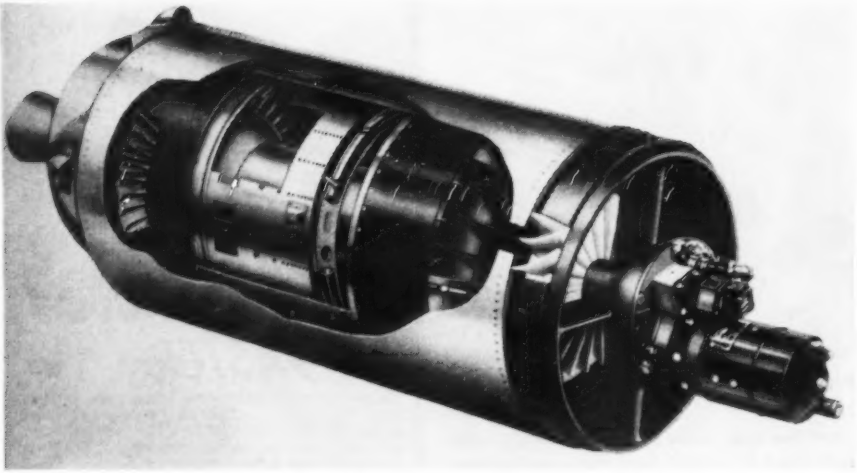

First cutaway view of the Fairchild J44 turbojet, in production by the engine division of the Fairchild Engine and Airplane Corp., Farmingdale, N. Y. An entirely new concept in jet engine design, the J44 features an outer sheet metal cowl which forms both a pressure chamber and a frame structure connecting the two main bearing supports, reducing the turbojet engine to its basic structural requirements. Currently being manufactured for target drone and missile applications, the jet provides more power in ratio to weight and compactness than ever before attained. In the 1000 lb. thrust power class and weighing 300 lb., the engine is 72" in length and 22" in diameter.

Designs in which the powerplant is cantilever-mounted without aft support are practical with the J44, due to the inherent rigidity of its monacoque structure. It can also be trunnion mounted as a pod under the wing of transports, to boost payloads on take-off. The J44 is adaptable to a wide range of altitudes and forward velocities. It was recently revealed as the powerplant in the Ryan Firebee Q-2, a pilotless target plane, which is a joint project of the Air Force, Army and Navy.

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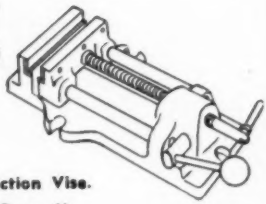

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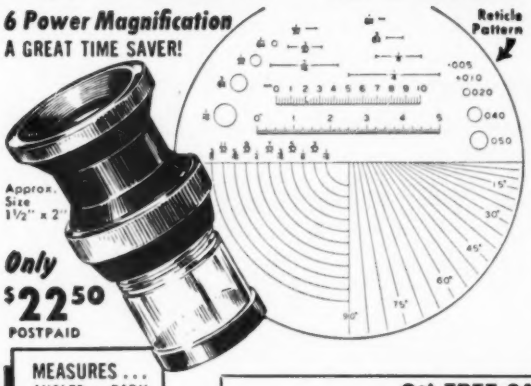

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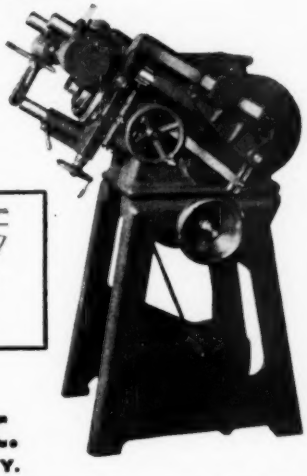

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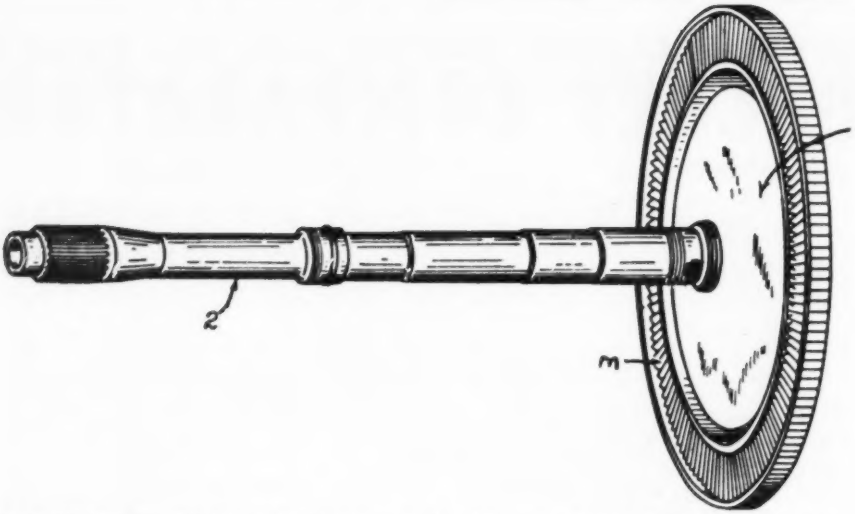

A shaft, disc or wheel and the buckets are the three main parts of a turbine wheel assembly; because of the extreme heat fluctuation, the internal stresses and the high centrifugal rate, these components must be able to take the worst sort of punishment. Number 1 indicates the wheel or disc, 2 the shaft and 3 the buckets.

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1 3/16"					6.60	9.20
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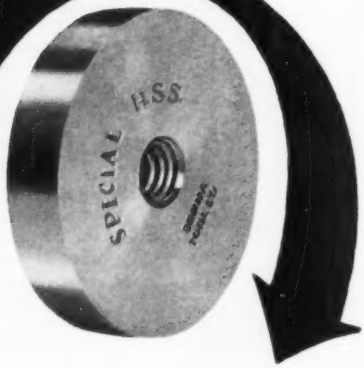

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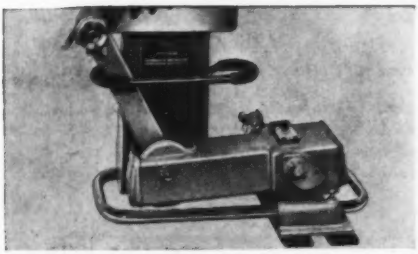

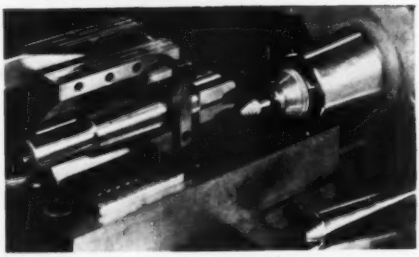

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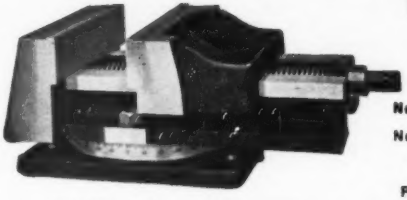

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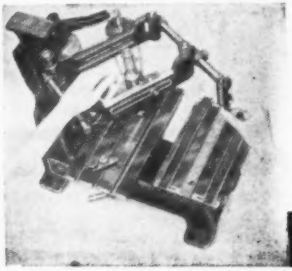

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Technical Books

Manual on Cutting of Metals with Single-Point Tools

By ASME Research Committee on Metal Cutting Data and Bibliography. Published by The American Society of Mechanical Engineers. Second edition. 546 pages.

The purpose of this book is to provide ready information for all those who are engaged in production work, from the foreman to the parts processing man. It should be of help to production departments in selecting the structure of the metal to be machined, the correct tool material, the size and shape of cut, and the appropriate use of cutting fluids; and also in determining power requirements and the best operating speeds for all jobs. Data on optimum cutting conditions will enable time-study departments to formulate operating standards and predicate production costs. The text covers all phases of machinability with respect to single-point tools.

The present volume enlarges upon the first in that it incorporates a more descriptive presentation of tool materials and their treatment, of new methods owing to new developments in metals, and offers much new material on the types, purposes and application of cutting fluids.

Review of Current Research and Directory of Member Institutions

(Engineering College Research Council of the American Society for Engineering Education)

Published at State College, Pennsylvania, by the Engineering College Research Council of the American Society for Engineering Education, 103 Mechanical Eng. Bldg., State College, Pa. Edited by V. E. Neilly, Secretary. 330 pages. Price $2.50.

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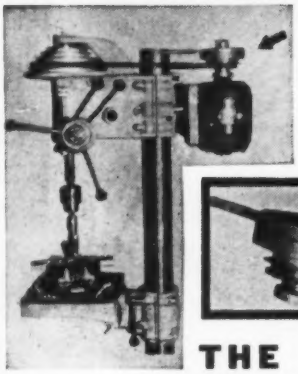

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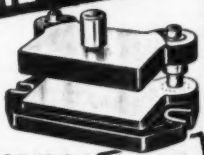

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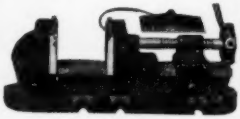

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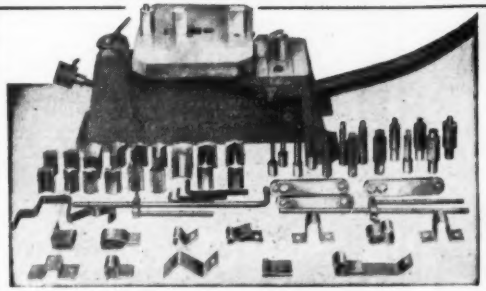

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Analysis of Aluminum Alloys

By G. H. Osborn and W. Stross. Published by Chemical Publishing Co., Inc., 212 Fifth Ave., New York, N.Y.; 144 pages, price. $3.50. Published under the auspices of ALAR, The Association of Light Alloy Refiners.

This is a survey of analytical methods many of which are new; others are modified versions of known methods, and a few are established standards, ranging from those requiring modern physico-chemical instruments, such as a polarograph and photometer, to those which may be carried out with the normal equipment available in the general chemical laboratory. Every method has been thoroughly tested by extensive application in industrial laboratories, according to the authors.

The book lists gravimetric, volumetric, electrolytic, photometric and polaragraphic methods for the determination of the most common elements such as copper, magnesium, silicon, iron, manganese, nickel, zinc, tin, antimony and chromium.

Methods for the determination of less common elements such as beryllium, bismuth, calcium, silver and sodium are also described.

Aluminum in Iron and Steel

By Samuel L. Case, technical adviser, Batelle Memorial Institute, and Kent R. Van Horn, director of research, Aluminum Corp. of America. Published for The Engineering Foundation by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, New York. Price: $8.50. 478 pages.

This is the first of a new monograph series of Alloys of Iron Research. It is planned to provide metallurgists and engineers with concise but comprehensive summaries of available data, as re-

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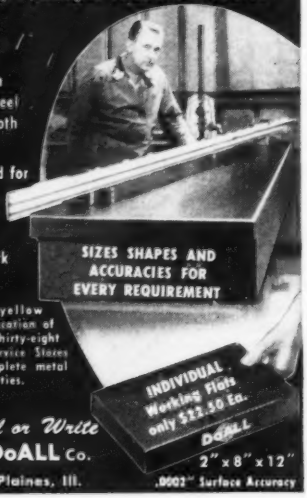

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Mathematical Physics

By Donald H. Menzel, professor of astrophysics, Harvard University. Published by Prentice-Hall, Inc., New York. 412 pages, price $11.35.

This volume, although primarily concerned with classical physics, specially emphasizes those topics closely related to modern phases, either in technique or subject matter. Several topics seldom presented, e.g., electron theory or general relativity, appear in considerable detail, because an understanding of them is increasingly vital to the student of atomic physics.

The book has been designed for use in junior, senior, or graduate courses in mathematical physics. All other phases of mathematics, function theory, vectors, matrices, dyadics, tensors, partial differential equations, etc., flow directly from the physics during the presentation of the various subjects. Such topics as existence theorems, convergence and high degree of mathematical rigor do not receive special emphasis because they chiefly concern the pure mathematician.

The Induction Motor

By Herbert Vickers, Ph.D., M. Eng., A. Inst. P., F.P.S.L., M.I.E.E., F.A.I.E.E., member of the Association of Consulting Engineers of London. Published by Pitman Publishing Corp., 2 W. 45th St., New York 36, N.Y. 531 pages. Price $15.00.

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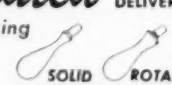

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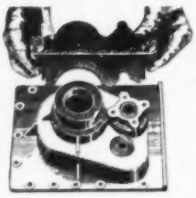

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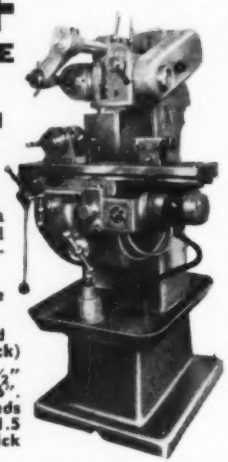

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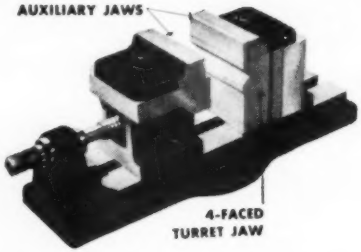

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Much additional material has been included dealing with single-phase machines, selsyns, the three-phase series and shunt commutator motors, a new theory of the single-phase motor, and the application of symmetrical components to conditions of unbalance. Fractional-horsepower motors are also dealt with and typical designs are worked out for single- and three-phase types; the book is invaluable to electrical engineers and also to students of electrical engineering design requiring a thorough treatment of the subject.

The Art of Lapidary

By Francis J. Sperisen, lapidary, San Francisco, Calif. Published by The Bruce Publishing Co., Milwaukee 1, Wis.; 382 pages, profusely illustrated. Price $8.50.

This very comprehensive volume on gems is fully illustrated with drawings of tools and equipment, working procedures, shapes and sizes of stones, and pictures of actual operation in performing the work. Carefully written but not difficult to follow, it does much to fill the gap that has existed since the origin of the lapidary art and the present-day practices in a language which can be understood by any intelligent person. Not only is equipment, such as the special lathes, discussed but methods of sawing, grinding, polishing and drilling are brought out in interesting detail. Two chapters are devoted to cabochon cutting and polishing and styles of cutting faceted stones. Much of the book deals with particular work such as engraving, carving mosaic, inlay, parquetry, diamond polishing, and industrial applications.

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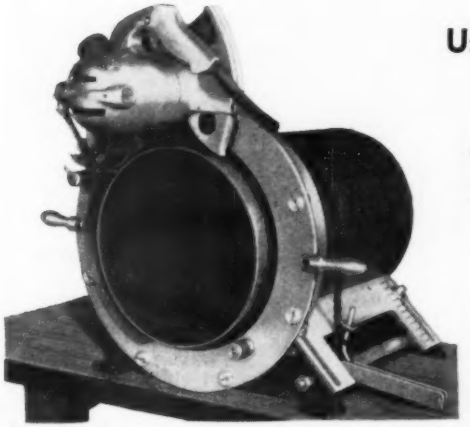

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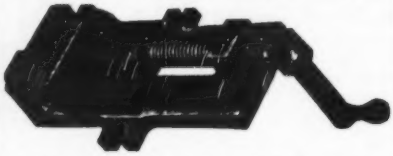

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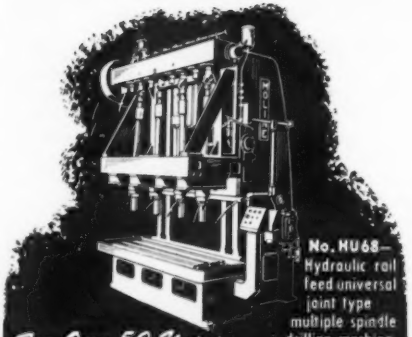

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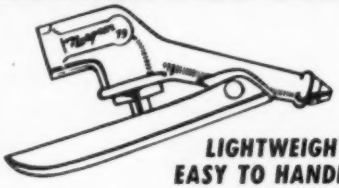

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Design of Machine Elements

By M. F. Spotts, professor of mechanical engineering, The Technological Institute, Northwestern University; second edition. Published by Prentice-Hall, Inc., 70 Fifth Ave., N. Y. 504 pages. Price $9.65.

This book is the outgrowth of over 25 years' experience in industry and in the classroom. The author has taught the contents many times to third and fourth year college students. Since the chapters are independent of each other, they can be studied in any order. If a complete machine is to be designed, the text will serve as a reference work or source book for information on the various elements. It is believed that engineers and designers in industry will find this book useful in their professional work.

Methods based on rational analysis have been utilized throughout the book. The well-known basic theories of design are clearly presented, as well as some of the newer methods now being employed. Mathematical derivations are given in full, but have been simplified

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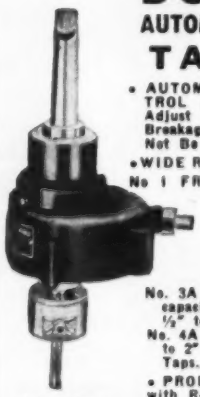

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wherever possible. Tables are included giving the properties of engineering materials as determined by laboratory tests; however, design data usually obtained from catalogs and handbooks have been omitted.

Metal Machining

By Lawrence E. Doyle, Reg. Prof. Engr., associate professor of mechanical engineering, University of Illinois. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N.Y.; 511 pages; price $10.00.

Original in its approach, this new book is an exceptionally thorough and comprehensive introduction to metal machining and process planning. It gives easy-to-grasp descriptions of metal machining equipment, methods, and techniques. Process planning is discussed in relation to each topic.

Major machine tools and operations begin with a rounded presentation of dimensions and tolerances, cutting tools, lathes and screw machines, shaping, planning, drilling, milling, boring, broaching, grinding, surface finishing and gear making. Every section has been purposely kept simple enough to be easily understood.

Profit Sharing, The Keystone of Industrial Peace

Proceedings of the fifth annual conference of the council of profit sharing industries, First National Tower, Akron, Ohio.

Interest in profit sharing has been at a higher level in the U.S. and Canada than at any time in its history. This is evidenced by the recent record of over 300 profit sharing and pension plans going through the Internal Revenue Dept. within one week—a rate several times higher than a few years ago.

Wage and salary stabilization agencies have made it extremely difficult to secure approval of a cash payment type plan. On the other hand, it has given impetus to the deferred or trusted type plan which they permit with certain restrictions. A recent report of the wage stablization agency stated that 4,000 pension plans and profit sharing plans were filed for approval between April and November of 1952 and that new applications were currently running at the rate of 100 per week.

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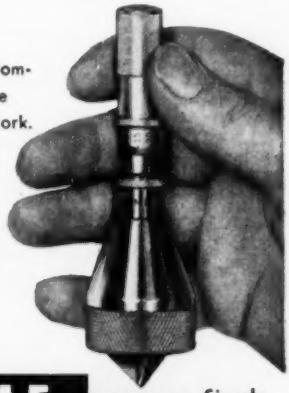

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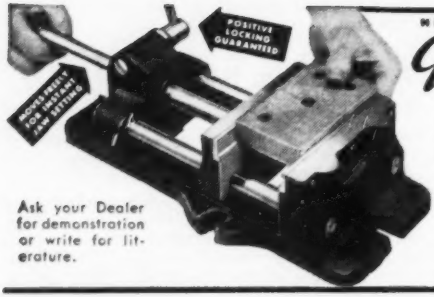

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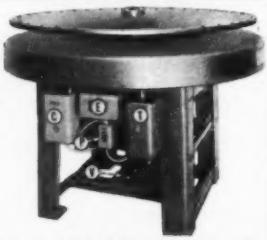

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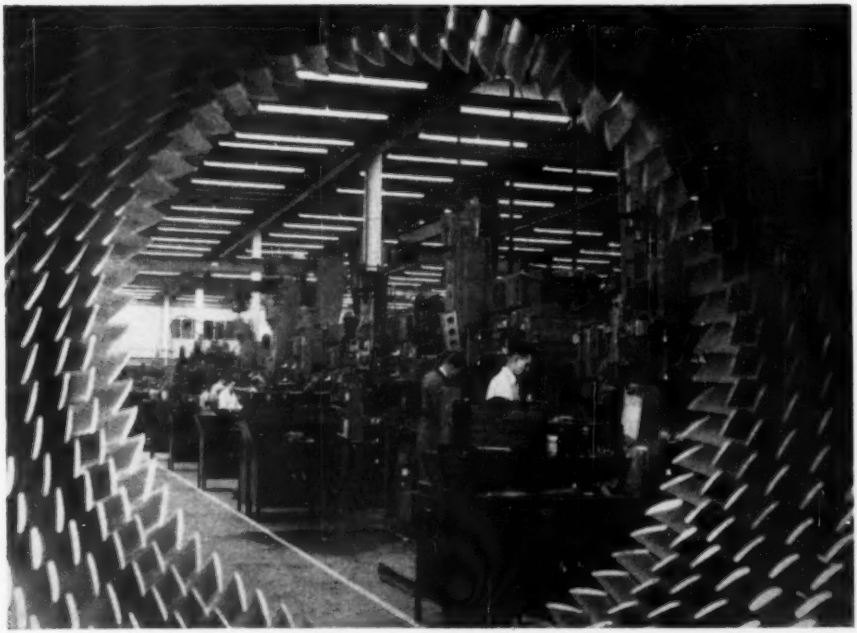
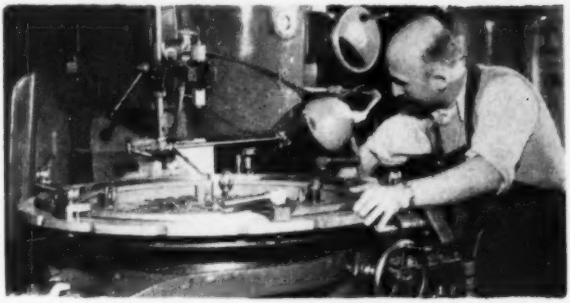
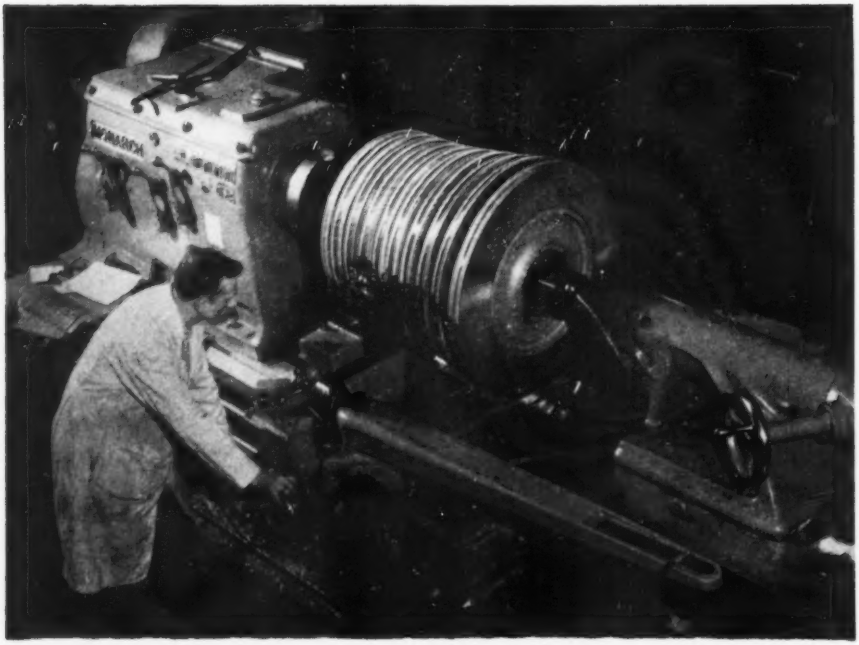
Random machining shots at new 708,000 sq. ft. plant; engine powers twin jet CF-100, all weather fighter, and F-86 Sabres with over 6500 pounds thrust



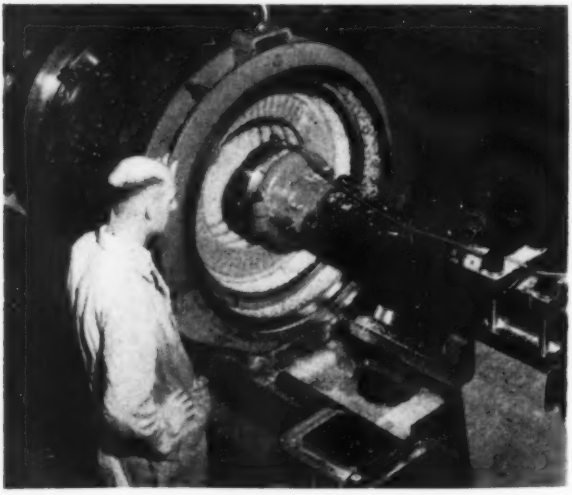
View of turbine disc line from inside compressor casing with blades.



Machining of retaining ring; note coolant jet at the cutting tool.



Blade tipping on rotor sub-assembly using Monarch air tracer.

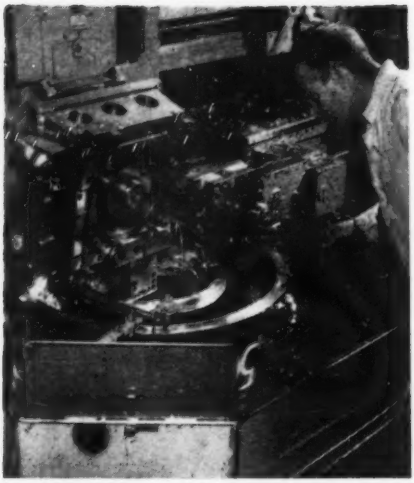


Blade tipping on the American tracer lathe. Blades are imbedded in wax to hold them in position.

Operation on magnesium intake casting on a King 36 Very horer with tracer control.

10th stage steel disc produced on Lodge & Shipley tracer lathe.

Drilling operation on aluminum center casting.



Roughing operation on magnesium intake casting.

Machining of turbine disc on a Man-Au-Tol vertical turret lathe.

New Carboloy cemented carbide

A heavy-duty steel cutting grade cemented carbide that is said to step up machining operations as much as 30% has been announced by Carboloy Dept. of General Electric Co., Detroit.

Grade 370 is reported to be capable of removing more cubic inches of steel per minute while providing up to 50% longer tool life. It was specially developed for taking heavy cuts at higher tool temperatures and is the first grade in a new carbide series. Another is expected to be announced early next year.

Tests by Carboloy engineers showed that on heavy duty machining applications, where heavy pressure and high temperature is encountered, other tools failed because the cutting edge deformed. Grade 370 is made with a new controlled manufacturing process which gives it built-in structural rigidity to resist this deformation, even at temperatures of 1800° F, it is claimed.

Users of grade 370 carbide blanks can expect longer production runs on heavy-duty steel cutting operations, according

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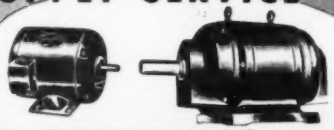

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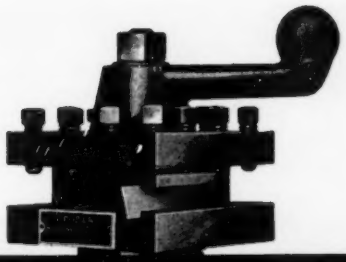

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1. Tool tipped with Carboloy grade 370 carbide blank handles a tough interrupted cutting job on a stator frame.

to results of 15 companies testing the carbide in the field on **across-the-board** machining jobs. These include turning of locomotive wheels and steel mill rolls, and machining heavy gun breech blocks, shells and turbine rotor shafts. The cutting edges of the carbide are said to have lasted up to 50% longer without deforming despite the high temperatures developed during the machining operations and the sudden high pressures applied on the edges due to interruptions.

Grade 370 is composed of tungsten carbide, titanium carbide, tantalum carbide and cobalt. It has a density of 12.60, and

2. Here tool is taking a 1¼" cut on a 75" dia. forging used for a cylinder head in a hydraulic steel forming press.

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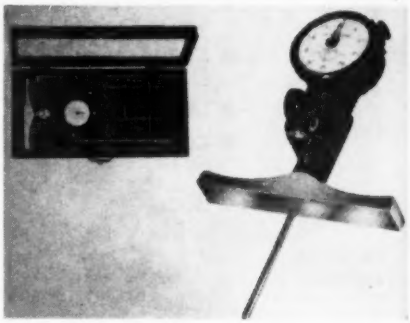
Rockwell hardness of A scale of 91.0.

Carboloy manufactures the material with controlled processing techniques which resulted from continued research to control the consistency of materials to close limits. It has been reported that the structure obtained is so rigid that, as a cutting tip, the carbide allows one-fourth to one-half more depth of cut at higher speeds.

One of the accompanying illustrations shows a closeup of machining a stator frame of cast alloy steel. It entails cutting through abrasive inclusions and, since the job calls for machining the tops of the stator frame ribs, the tool is making a series of interrupted cuts. Chipping, the main cause of tool failure on this job, is reportedly reduced with the use of grade 370. Tool used in the operation has a 20° negative back rake, 8° positive side rake and end-cutting edge angle of 5°. It also has a lead angle of 45°. The clearance angle on the carbide tip is 5° with 7° being allowed on the steel shank or holder below the tip. The carbide blank is on a 1½"x1½"x8" shank, and the tip of the tool is positioned to sit above the top of the shank in order to allow maximum support under the tip.

Depth and groove location gage

The dial indicator depth gage manufactured by Reliant Industries, 4947-B Firestone Blvd., South Gate, Calif., is said to be fully adjustable from 0" to 6-¾"



without changing measuring rods. Gage is light and well-balanced. The design allows checking to close tolerances with single dial standard range indicators without the necessity of counting dial revolutions.

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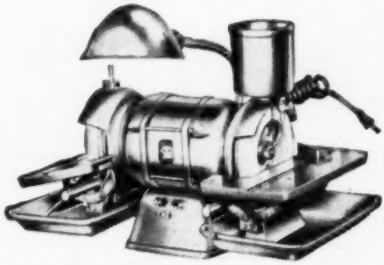
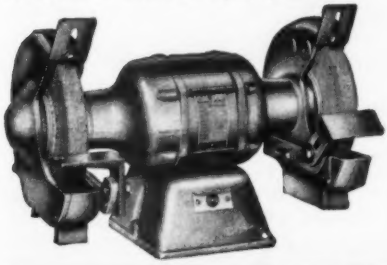
Special Carbide Tool Grinder

BALDOR Grinder No. 500—built especially for sharpening carbide tools quickly and accurately. Reversible ½ h.p., capacitor type Baldor motor; heavy shaft, large ball-bearings. Dynamically balanced armature. Motor withstands repeated overloads. Protractor at each end of grinder. Complete as shown at right, **$149.20**





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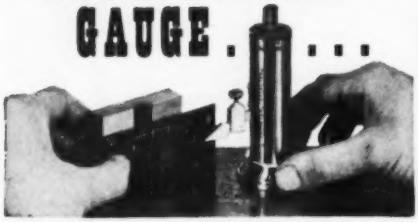

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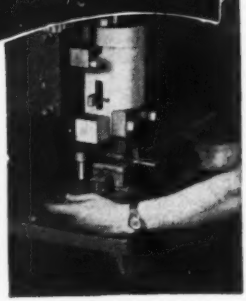

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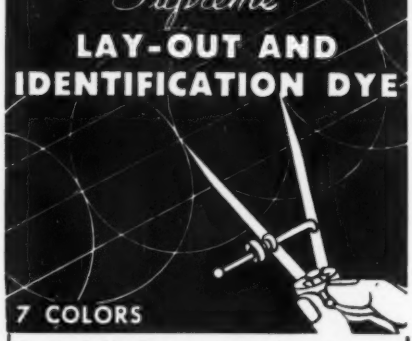

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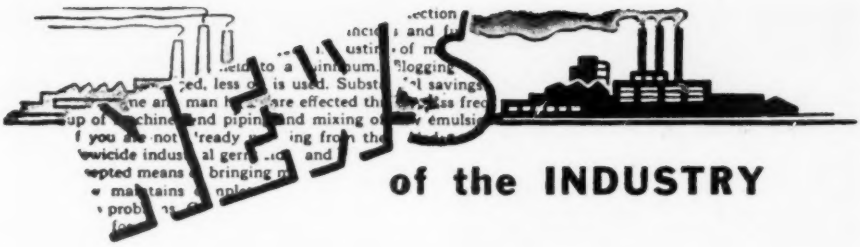


Carborundum's Traveling Workshop, an Innovation in Mobile Selling, Self-Contained

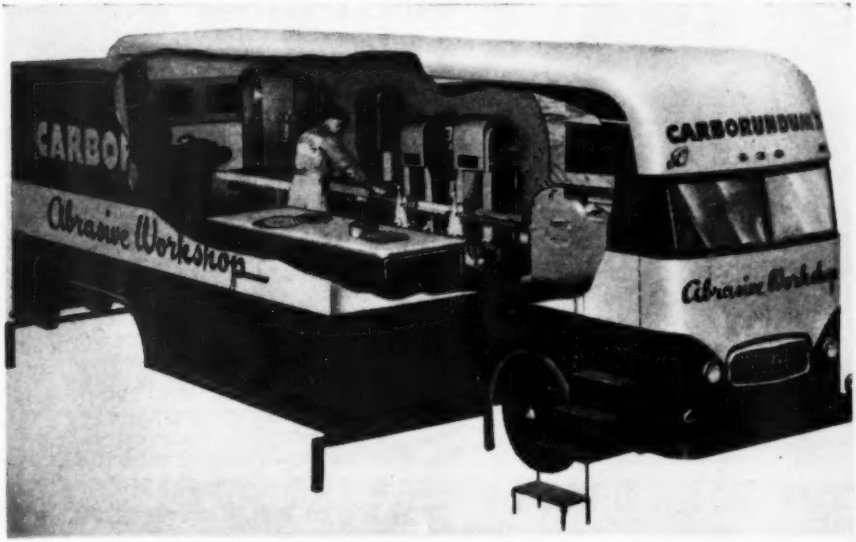
"CARBORUNDUM'S ABRASIVE Workshop" is equipped to demonstrate coated abrasive grinding under actual production conditions; first of its kind in industry, the traveling workshop will carry the story of the Niagara Falls company's coated abrasive products to customers and prospects throughout the entire country.

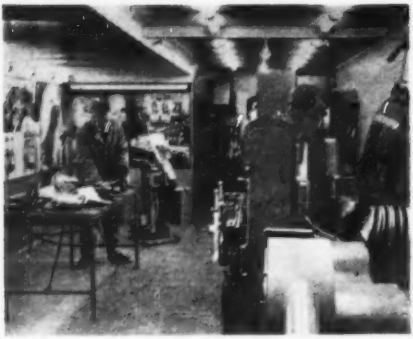
The 35-foot long, 12½-foot high vehicle contains the means for showing the abrasive products in use and how applications of them can benefit users.

Contained in the 19-ton workshop is a total of eight stationary coated abrasive grinding machines and a variety of portable tools.

Perhaps the most novel feature of the vehicle is the expanding sidewall, which increases the effective width of the workshop to a total of 15 feet when the unit is stationary. This provides a seating capacity for an audience of about 12 to 15 people when demonstrations are underway.

The vehicle is completely self-contained. It supplies its own power to operate the





machine tools and the interior fluorescent lighting and heat or air conditioning. Two five-ton air conditioners provide audience comfort and operate a dust-disposal unit used in conjunction with the grinding machines. A small compressor is available to power the portable tools.

In addition to the abrasive machines, the vehicle has a complete sound system, incorporating a message repeater, a sound motion picture system, and a library of literature describing the abrasive tools and their applications.

A radio-telephone is also installed to permit ready contact with the vehicle at all times.

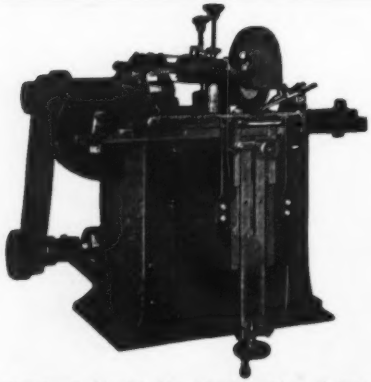
Driver comfort has also been considered, and comfortable seating, an AM and FM radio and power steering have been provided.

More than 20 grinding demonstrations have been devised, representing a wide variety of typical grinding operations. Only a selected grouping will be presented at any one time, however, in keeping with the interests of the audience.

Two Carborundum engineers accompany the Abrasive Workshop and conduct the demonstrations. The vehicle was custom built by the Gerstenslager Co., Wooster, Ohio. Exterior and interior designing was performed by Norman Hadley Displays, Buffalo.

Acquire deep hole drilling equipment

Acromatic Tool Co., Box 56, College Park Station, Detroit 21, Mich., recently acquired the deep hole drilling equipment formerly operated by the Conner Tool and Cutter Co., Detroit, Mich., and Sullivan, Ind.



Wardwell Model EC Combination Grinder The only single unit grinder adaptable for hack, band and circular saws that does not depend on the shape of the grinding wheel to form the shape of the tooth. • This unique feature enables operator to grind a variety of blades without dressing or changing wheels.

sharpening 1 gross of hack saw blades PAYS for this machine!

One gross of hack saw blades can be resharpened at least 6 times—actually saving you the price of the machine!

Wardwell EC Grinder gives old blades a keener, longer lasting cutting edge—because new blades are usually not ground after hardening.

Wardwell EC wheels will not burn, anneal or injure hardness of teeth. Sharpen Circular, Hack or Band Saw blades on one machine!

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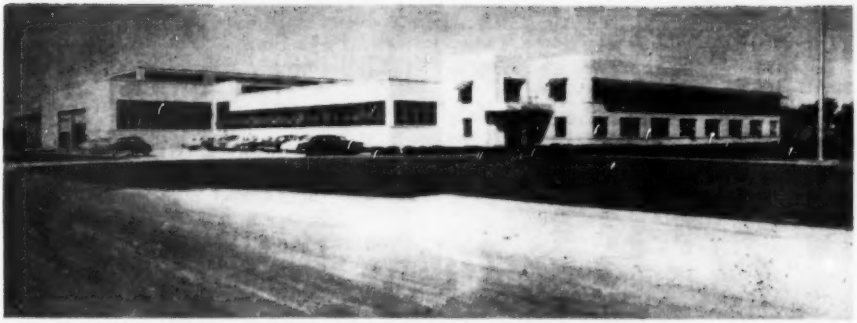


Brust Tool Mfg. Co. has opened a new plant in Franklin Park (Chicago suburb), Ill. With the opening of the new plant, **I. M. Brust,** president, announces a four-point service with **James Carroll,** executive vice-president, in charge of operations: design and engineering; special custom-built high-production machinery; tools and dies; and a production service on precision parts and products.

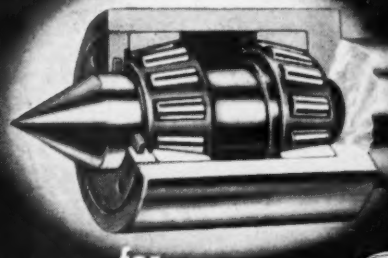
John L. MacDonald, former Thor Boston district industrial tool service engineer, has been named manager of Thor's newly opened Newark, N.J., factory branch office.

A. Milne & Co. moves Chicago office and warehouse

A. Milne & Co. recently announced that they have moved their Chicago office and warehouse to larger facilities in a new building constructed for the com-

...accurate beyond comparison

Falls ROTO CENTER



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pany at 2080 N. Hawthorne Ave., Melrose Park, Ill.

The new branch is under the management of **H. S. Hoyt, Jr.**

The Motch & Merryweather Machinery Co., Cleveland, Ohio, has announced the recent appointment of **A. J. Snyder** as sales manager of the cutting tool sales division. Snyder was formerly vice-president and general manager of the Morse Twist Drill Co. of New Bedford, Mass.

The appointment of **Ray F. Ellis** as director of sales and **Burleigh L. Owens** as director of marketing at the Atkins Saw Div. of Borg-Warner Corp., Indianapolis, has been announced. Both Ellis and Owens were assistants to the vice-president, sales.

Appointment of **A. William Tilder** as sales manager of the guide pin and bushing div. of Lamina Dies & Tools, Inc., Berkley, Mich., has been announced. Prior to joining Lamina, Tilder was vice-president and general manager of the Acromatic Tool Co.

A. J. Snyder

Ray F. Ellis

Burleigh L. Owens

A. William Tilder

When so much depends on so little

Don't settle for less than "Chicago" High Carbon Heat Treated Cap Screws

- **For complete hardness from the center all the way out — no soft skin to cause wear or breakage due to fatigue.**
- **For freedom from scale — cleaner to handle — give a tighter thread fit — have smoother bodies.**
- **For extra safety — better appearance — ALL at no increase in cost to you.**

Your Service-Conscious Industrial Supply Distributor carries a complete stock of our products. Ask him for samples of "Chicago" Heat Treated Cap Screws. His familiarity with your local field conditions enables him to fill your supply needs promptly and correctly. Ask for "Chicago" and get better service.

You get these advantages with "Chicago" Heat-Treated Cap Screws

Corners stay sharp . . . provide positive non-slip wrench grip . . . No decarburized surface.

Bodies wear longer . . . nominal diameter remains to size . . . No decarburized surface.

Threads without nicks..hold tighter in engagement . . . No decarburized surface.

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2507 WASHINGTON BOULEVARD
BELLWOOD ILLINOIS

SAWING FILING

GROB BROTHERS

GRAFTON WISCONSIN

PALMGREN

ROTARY, INDEX, MILLING TABLE
The ONLY TABLE Having ROTARY FEED
Combined With
DUAL CROSS FEEDS

No. 83

Now Only! $54.50

Turns Your DRILL PRESS Into A VERTICAL MILLER

This PALMGREN TABLE is sensational in price, construction and performance. Just what shops need for accurate, precision work. You can mill straight or curved, slot, drill, also rout, rabbet, mortise and sand on wood. Do hundreds of jobs as milling slots, grooves, keyways, squares, hexagons, curves, flats, dovetails, indexing and laying out work.

Designed for use on Drill Press or Milling Machine. It handles all types of metal and woodworking operations and makes your drill press a vertical milling machine. Precision built. It permits close tolerances. Rotary Feed is calibrated in degrees. Cross Feeds in thousandths. Cross slides and feeds are 2 ¼" each side of center—4 ½" overall. Has Acme thread cross feed screws, adjustable gibs on cross slides—40 to 1 worm and gear ratio in rotary feed. 4 Bolt slots—2 lock screws.

No. 83 Table Dia. 8", T-Slots ⅝", Base Keyway ⅝", Base Dia. 6¾", Ht. 5", Wt. 37 lbs. Price $54.50

Order Today! Write for New Catalog No. 201

CHICAGO TOOL and ENGINEERING CO.
8384 South Chicago Avenue, Chicago 17, Ill.

W.H.O.* SAYS:

"Don't have FITS over FASTENERS, have fasteners that fit."

For the finest in milled-from-the-bar cap screws, set screws, coupling bolts and milled studs

DON'T GET STUCK, STICK TO THE ONES MADE BY

* Wm. H. Ottemiller Co. YORK, PA.

STEEL Stanho PRODUCTS

the Quality Line

- WOODRUFF KEYS
- MACHINE KEYS
- MACHINE RACK
- TAPER PINS
- COTTER PINS
- SPECIAL PARTS

and other Stanho products
Bulk or Packaged

WRITE for CATALOG and PRICES

STANDARD HORSE NAIL CORP.
Since 1872
NEW BRIGHTON, PA

Philip M. McKenna receives the Holley medal from ASME

The Holley Medal, an honor conferred for a unique act of genius of an engineering nature, was given to **Philip M. McKenna** by the American Society of Mechanical Engineers at its annual meeting, Dec. 2, in New York.

McKenna was cited "for his research, development, and application of cemented carbide compositions which have contributed so much to the art and science of metal cutting." He is internationally known as a metallurgist, inventor, industrialist, and monetary economist and is president of Kennametal Inc., Latrobe, Pa., and national chairman of The Gold Standard League.

His special interest is "to restore sound currency, through the return to the gold coin standard in the United States." The fifteenth recipient of the Towne Lectureship, he delivered his lecture entitled "Economics and the Engineer" Dec. 1.

The Lecture is in honor of Henry Robinson Towne, president of The American Society of Mechanical Engineers in 1889, whose paper in 1886 on "The Engineer as an Economist" initiated the flow of valuable Society contributions on scientific management. The Towne Lecture gives opportunity for an outstanding leader in the field of management, economics, or business to reveal his experience, preferably related to the scientific method in industry or business. A certificate is presented to the lecturer.

Correction: In the Super-Cut advertisement of the $45.00 Single Layer Diamond Wheel which appeared in our December, 1953 issue, the incorrect dimensions of the wheel appeared. The advertisement read 6" dia., 3¼" face. The correct dimensions should have been 6" dia., ¾" face.

Continental

CHASER AND CUT-OFF WHEEL GRINDER

Keeps tools sharp

One machine does both—it sharpens pipe thread chasers at one end—and pipe and tube cut-off wheels at the other end. Keeps your tools ready for instant use—always sharp. *Also, Manufacturers of Cut-Off Machines and Wheels.*

Request Circular, Today.

Continental MACHINE CO.
SINCE 1919
1952 N. MAUD AVE. • CHICAGO 14, ILL.

N.M.T.B.A. elects new officers; H. L. Tigges named president

Herbert L. Tigges, executive vice president, Baker Brothers, Inc., Toledo, Ohio, was elected president of the National Machine Tool Builders' Ass'n. at its 52nd

H. L. Tigges

M. A. Hollengreen

Annual Meeting held at the Boca Raton Hotel and Club, Boca Raton, Florida, recently.

Milburn A. Hollengreen, president and general manager, Landis Tool Co., Waynesboro, Pa., was elected 1st vice president; and **Louis Polk**, president of the Sheffield Corp., Dayton, Ohio, was

Louis Polk

J. C. Cotner

elected 2nd vice president and director; **John C. Cotner**, president and general manager of the Hydraulic Press Mfg. Co., Mount Gilead, Ohio, was elected treasurer.

New directors elected, in addition to Mr. Polk, were: **Everett M. Hicks**, vice president and manager of the Grinding Machine Div., Norton Co., Worcester, Mass., and **William E. Rutz**, executive vice president and works manager, Giddings & Lewis Machine Tool Co., Fond du Lac, Wis.

Tell Berna was reappointed general

STOP DUSTS INSTANTLY

with

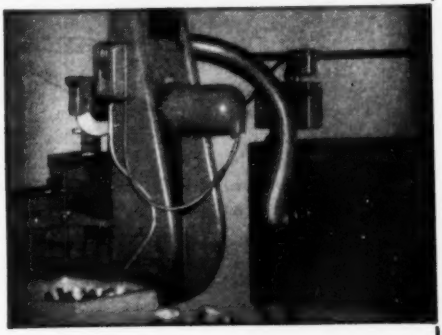
DUSTKOP

Available from stock of 32 standard models

300 cfm to 10,000 cfm

for: Surface Grinders, Tool and Cutter Grinders; Polishers and Buffers; Abrasive Belts and Discs; Woodworking and Plastic Industry Equipment . . . DUSTKOPS collect almost all kinds of industrial dusts.

Ask for Catalog 605-3. Describe dust problems for recommendation by return mail — no obligation.



AGET-DETROIT CO.

502 Main St. Ann Arbor, Michigan

E. M. Hicks

Wm. E. Rutz

manager of the association. **Mrs. Frida F. Selbert** was re-elected secretary.

Five join ASTE research fund group

Election of five more American industrial leaders to the American Society of Tool Engineers' Research Fund Committee is announced by Roger F. Waindle, ASTE president. They are: Wallace E. Carroll, president of American Gage & Machine Co., Affiliated Screw Products Co., Sebold Mfg. Co., and Porter Mfg. Co., all of the Chicago area, and a director of the Alpha Corp., Greenwich, Conn.; Ralph J. Kraut, president of Giddings and Lewis Machine Tool Co., Fond du Lac, Wis., and chairman of the board of Kaukauna Machine Corp., Kaukauna, Wis; W. E. Mahin, technical director, Research Center of Vanadium Corp. of America, Cambridge, Ohio, and special consultant to the Minerals and Metals Advisory Board of National Research Council and the Ship Steels Committee of the National Academy of Science; Col. Dan Martin, vice president in charge of engineering at Hughes Tool Co., Houston, Tex., and vice president of the American Ordnance Association; Joseph Sunnen, president of Sunnen Products Co. of St. Louis, Mo.

Robert B. Douglas, past president of the ASTE, is chairman of the committee. Douglas is president of Godscroft Industries and Specialloid Inc., Ltd., of Montreal, Canada. He has served as chairman since the committee was established in 1952.

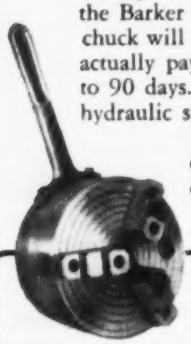
Holdover members of the committee also include Roger E. Gay, president of Bristol Brass Co., Bristol, Conn., and Louis F. Polk, president of Sheffield Corp., Dayton, Ohio.

Labor Saving Production CHUCK

Will pay for itself in 60 to 90 days

On turrets, engine lathes, cutting-off machines, drill presses or any type of chucking machine, the Barker Two-Jaw or Three-Jaw hand operated chuck will increase production up to one third and actually pay for itself while doing it in from 60 to 90 days. Hand lever eliminates pneumatic and hydraulic systems, yet closes and locks jaws with lathe running or stopped. Over 30 years of labor saving, production boosting operation.

Write for bulletin 201 today.



CHUCK DIVISION
THOMAS HOIST CO.
24 S. HOYNE CHICAGO 12, ILL.

Warner & Swasey wins award for machine tool ads second time this year

Carl F. Toll (left), vice president of the Cleveland Advertising Club, presents two plaques to **Walter K. Bailey**, manufacturing vice president of the Warner & Swasey Co., builders of precision ma-

chinery, Cleveland, Ohio. This marks the second time this year the company has won awards for its institutional and machine tool ads. Earlier this year Warner & Swasey won two "topper" awards for their institutional and machine tool ads from the National Industrial Advertisers Association. The company's machine tool ads have been appearing in **MACHINE** and **TOOL BLUE BOOK.**

Carpenter expands Milwaukee facilities

An open house commemorating the opening of a new mill-branch warehouse and office for the Carpenter Steel Co. at

4152 N. 35th St., Milwaukee, Wis., was held recently.

F. P. McCahan, branch manager for Carpenter, is in charge of the Milwaukee addition. It is also the headquarters for **C. W. Windfelder,** assistant to the vice-president, and **O. L. Richards,** representative.

Tighten the Reins – Stop Loose Buying

Use **NUPLA** hammers

The one soft-faced line serving all industry

with interchangeable NUPLAFLEX tips

MIGHTY— but gentle

SIMPLIFY—SAVE INVENTORY NUPLA hammers with their complete size and weight selection do the **whole** job... easily interchangeable NUPLAFLEX TIPS in 5 hardnesses meet all soft-faced pounding requirements... replace rubber, rawhide, lead, plastic and all other lines of soft-faced hammers.

HAVE TREMENDOUS ECONOMY APPEAL Super-durable NUPLA hammers have **proved** to outwear ordinary hammers 10-50 to 1... and have played important roles in many cost reduction programs. Write for actual case histories.

THE CHOICE OF INDUSTRY Many users **specify** NUPLA with NUPLAFLEX TIPS, including General Motors, Chrysler, Allis-Chalmers, Ford, Lockheed, Westinghouse, the Army, Navy and Air Force.

WORKERS PREFER THEM NUPLA hammers provide solid blows without sting... reduce fatigue. Also safety tools... non-chipping, no flying particles, sparkproof.

New Plastic Corporation,
1026 North Sycamore, Dept. No. 100, Los Angeles 38, California

Please tell me how to increase the efficiency and reduce the costs of my pounding operations with NUPLA hammers.

Name_____

Street Address_____

City_____ Zone____ State_____

Franke Gear buys Speedy Electric Glass Washer

Franke Gear Works, Inc., Chicago, has announced the purchase of controlling interest in Speedy Electric Glass Washer Co., Chicago. The latter firm manufactures portable electric multiple rotary brush washers for dishes, glasses, etc.

Grobet File opens Detroit branch office and warehouse

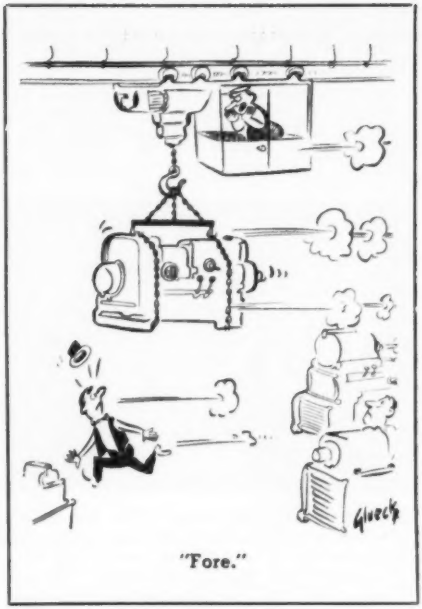
Jean M. Robert, president of the Grobet File Company of America, New York City, announces the opening of a new branch at Hazel Park, Mich., under the management of **Donald MacKay.**

A stock of 5000 shapes and sizes of Swiss files, rotary files, burs, countersinks and specialties will be carried for service to Michigan, northern Indiana and western Ohio.

Rice Pump moves

Rice Pump & Machine Co., formerly of Grafton, Wis., has moved to new and larger headquarters at Belgium, Wis.

Floor space for their manufacture of die filers and profile grinders has been tripled over that of the Grafton location.



"Fore."

All-purpose Centrifugal Pump Unit No. H-2-3308A for 90% of machine tool applications

Gear Pump Unit No. SG1-4-25A Ideal for single spindle drill presses and small lathes

See how GRAYMILLS Coolant Pumps can help you

- **convert to wet cutting or**
- **replace worn out pumps**

in a matter of minutes for increased production—improved quality—and longer tool life with your present machine tools.

If you need a larger volume of coolant, cutting oils, water, solvents, etc., at low pressures, the new improved Graymills Centrifugal coolant pumps are your answer. If you need higher pressures, for heavier liquids, a Graymills Gear type pumping unit will deliver from 1 to 3 GPM with pressures up to 100 PSI. Both types will give longer, trouble-free service. efficient operation at a minimum of cost. Standard models in 1/25, ⅛, ¼ and ½ H.P. Various tank sizes and fittings.

All standard models stocked by leading Industrial Supply Distributors for immediate delivery—or write for catalog.

GRAY-MILLS

GRAYMILLS CORPORATION 3721 N. LINCOLN AVE. • CHICAGO 13, ILL.

WEST COAST: 4511 MELROSE AVE., LOS ANGELES 29

MECHANICS THROUGH THE AGES

189 Fascinating Facts about technical developments throughout man's recorded history. Highly educational. Entertaining, cartoon style. 64 pages. Only ONE DOLLAR per copy.

Here's a book you'll refer to time and time again. You'll chuckle at the old methods used in metalworking. You'll be surprised at the origin of certain present day practices. "Mechanics Through the Ages" is a collection of the best full pages appearing under the same name every month in Machine and Tool Blue Book. 63 of these pages have been selected to make one of the most fascinating books ever published on technical progress. You'll want several copies to give to friends and associates. **Only $1.00 each.** Postpaid if check accompanies order.

Book makes an ideal gift for customers and employees. Mail your Hard laminated attractively designed covers. order to

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Wheaton, Illinois

MAIL THIS ORDER TODAY

Send _____ copies "Mechanics Through the Ages" to:

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Company_____

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City_____ Zone_____ State_____

Enclosed is remittance for $_____. Ship postpaid.

The MARKET PLACE

Advertisements acceptable in THE MARKET PLACE include those for employment, sales services, production facilities, representation and related needs. **Rates: $12 per column inch per insertion. Maximum size advertisement accepted in this section is two inches.**

Copy should reach us by the first of the month for next month's issue.

MACHINE and TOOL BLUE BOOK **A Hitchcock Publication** **Wheaton, Ill.**

IMPORTED PRECISION TOOLS

Vernier Calipers up to 80" - Height gages up to 48" at savings up to 40% to the user and excellent proposition for dealers.

RADIAL DRILLS & VERTICAL MILLS

Territories Open **We Carry the Tools in Stock**

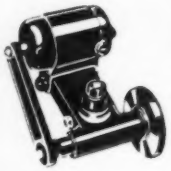
Box 215 c/o MACHINE and TOOL BLUE BOOK Wheaton, Ill.

DIAMOND WHEELS

Sales distributor opportunity for complete line. Prompt delivery of finest diamond wheels available in all sizes for tool grinding. **NATIONALLY KNOWN MANUFACTURER INCREASING DISTRIBUTION.** Will appoint distributors who specialize primarily in selling cutting tools to industrial accounts. Write for details of our sales and service program in your territory.

UNITED STATES DIAMOND WHEEL COMPANY

1835 Illinois Ave. **Aurora, Illinois**



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NEW TOOL POST GRINDERS

REGULAR PRICE $125.00

$39.50

Less Grinding wheel

1/6 H.P. MOTOR

Takes Wheels up to ½" x 4"

Extra Quill Ext. or Internal $19.50

Money Back Guarantee

EDWARD J. NOLAN

PULASKI, NEW YORK

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To Your Specifications

Prompt Quotations

BALDT ANCHOR CHAIN & FORGE DIVISION

P. O. Box 350 **Chester, Pennsylvania**

ACETATE SHEETS

UP TO 1/4" THICK

Sheet sizes

20" x 50"

Ideal for Machine Guards Windows Safety Shields Blue Print Covers

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GEARED HEAD RADIAL DRILL PRESSES
LOW COST VERTICAL MILLING MACHINES

Full Line of Vernier Calipers and Height Gages

Splendid Opportunity for Dealers

Masters **3613 ARCHER** **CHICAGO 9, ILL.**

The First Name

WITH THE VERY BEST FACILITIES

DAYTON ROGERS
Manufacturing Company

MINNEAPOLIS 7, MINN.
Represented Nationally in Principal Cities

Well known manufacturer of cast cutting tools requires agents for Chicago, States of Illinois, Wisconsin and Minnesota. Only persons or companies with good knowledge of cutting tools need apply to

Room 1204
415 Lexington Ave., New York 17, N.Y.

ANOTHER LINE

of machine tools or related equipment can be handled in the middle west by an established aggressive manufacturer's agent who is now contracting distributors and industrial accounts. Present principals know of this advertisement.

MACHINE and TOOL BLUE BOOK
BOX 217
WHEATON, ILLINOIS

ABRASIVES

7/8 - 1 3/8 - 1 7/8 dia. slotted discs
1/8 dia. Spiracords
All above 100 grit
3/4 x 1 1/2 80 grit cartridge rolls
This surplus stock available at fraction of cost.

PRECISION SUPPLY
12-36 River Road Fair Lawn, N. J.
FA 6-0420

SPECIALTY MACHINE WORK

High Precision Dividing, Both Linear and Circular on Dials, Scales, Verniers, etc.

Tracer Controlled Lathe Work. Stepped Shafts, Turned Contours, etc.

We invite your inquiries.

F. T. GRISWOLD MFG. CO.
Lancaster Avenue, Devon, Penna.
PHONE WAYNE 4080-4081

The world's best . . . one-piece, drop-forged—not welded—of mild carbon steel, heat-treated, with head accurately milled for standard tables on lathes, planers, boring mills, milling machines. Integral washer and nut. Sizes: up to 30". Typical direct prices for 10" lengths: 1/2—$1.36; 5/8—$1.38; 3/4—$1.58; 7/8—$1.80. Write for price list.

THE O K TOOL COMPANY
MILFORD 7, NEW HAMPSHIRE

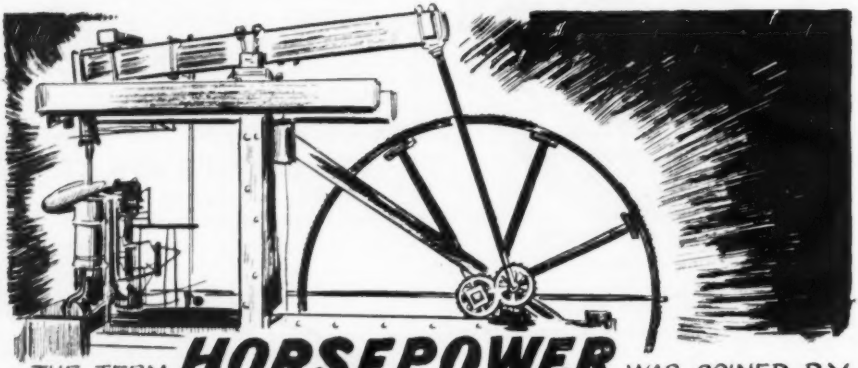
WANTED—MANUFACTURERS REPRESENTATIVE

Contact man now calling on Executive Engineers or top level engineering management required by manufacturer of high precision Universal Grinder. All territories open.

Box 219
c/o Machine and Tool Blue Book
WHEATON, ILLINOIS

Mention MACHINE and TOOL BLUE BOOK when writing advertisers

Mechanics Through The Ages



THE TERM **HORSEPOWER** WAS COINED BY JAMES WATT, FAMED 18TH CENTURY PIONEER STEAM ENGINE BUILDER, WHO, AFTER COMPUTING THAT THE AVERAGE WORK HORSE COULD RAISE 22,000 POUNDS ONE FOOT A MINUTE OFFERED TO SELL HIS ENGINES ON THE BASIS THAT ONE HORSEPOWER EQUALLED 33,000 FOOT POUNDS A MINUTE!

IN 1296 THE PRACTICE OF PEDDLING ARMOR IN THE STREETS OF PARIS WAS FORBIDDEN TO ALL EXCEPT POOR MEMBERS OF THE ARMORERS CRAFT WHO COULD SWEAR THAT THEY MADE THE ARMOR THEMSELVES — IN THEIR OWN HOUSES!

IN THE 1600's THE KNIFEMAKERS AND CUTLERS OF HALLAMSHIRE, ENGLAND, WERE NOT PERMITTED TO WORK DURING THE 28 DAYS OF EACH YEAR FOLLOWING THE 28TH OF AUGUST, AND FROM CHRISTMAS TO THE 23RD OF JANUARY!

Gil Reety

THE DIE IS CAST...

Then finished in 14 Seconds with the Cri-Dan "B"

Yes, the die is cast at Western Die Casting Company for the Cri-Dan "B". After the pulley is cast, the Cri-Dan bores and chamfers the hole, faces the flange and generates the thread—SIMULTANEOUSLY!

Tool life? Over ten thousand pieces per grind. The secret of this amazing efficiency is the ability of the Cri-Dan to fully utilize the single point carbide tool in threading.

If you want all the facts on Cri-Dan threading machines, contact your Lees-Bradner representative or write direct.

the LEES-BRADNER Company

CLEVELAND 11, OHIO, U.S.A.

You, too, can

SPEED UP

METAL-CUTTING JOBS

Like This Famous Industrial Plant Does

Report From
Allis-Chalmers Manufacturing Co. Milwaukee Plant

Machine
Kling Friction Saw

Jobs Performed
Cutting channels, angles, round, square and flat bar stock.

Average Cuts Per Day
1000 to 1300 per 8 hours

What Does It Replace?
Kling Friction Saw in use from January 1928 to July 1953.

Kling HIGH SPEED FRICTION SAWS

cut cutting-time **IN THE "BEST OF COMPANIES!"***

Can you cut 24" 100 lb. I-Beams in 28 seconds...15" 55 lb. Channels in 15 seconds...8" x 8" x ¾" Angles in 11 seconds? These are only a few examples of what the Kling High-Speed Friction Saw is doing daily in many of the country's most important metal working plants. No wonder Kling Machines are attracting "top-level" attention!

Friction Sawing works differently—cuts metal by generating heat through friction, on to the part to be cut, at a rate faster than the part can absorb heat. Kling Friction Saws cut all types of steel, hard or soft, large or small, in any shape, without distortion, and without change of blade or set-up.

The average Kling Friction Saw blade will give a full day's production before requiring redressing, thus eliminating costly downtime and saving on tool costs.

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International Harvester Co. Jones and Laughlin Steel Corp.
Kaiser Steel Corp. Link-Belt Co. Madsen Iron Works, Inc.
Maryland Dry Dock Corp. Shell Oil Co.
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Complete Friction Sawing Information FREE! Write for 12-page Bulletin No. 9200 that tells you in detail, exactly how Friction Saws work and what they can do in your shop to save you time and money.

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473MM

Since 1892 **Kling** ***...an investment in speed!***

Whatever You Need, You'll Find It Here

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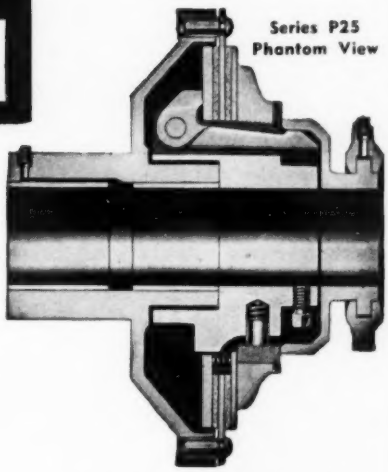

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2. Pitch diameter and concentricity of spur, helical or worm gears	√	√	√	√	√
3. Root diameter of spur, helical or worm gears	√	√	√	√	√
4. Outside diameter—Odd number or even number of teeth	√	√	√	√	√
5. Crown or taper condition of spur or helical gears	√	√	√	√	√
6. Direct check with mating or master gears using rolling attachment	√	√	√	√	√
7. Outside diameter of gear blanks	√	√	√	√	√
8. Parallelism of spur gears		√	√	√	√
9. Helix angle of right or left hand gears		√	√	√	√
10. Tooth spacing—tooth to tooth		√	√	√	√
11. Tooth spacing—at 180 degrees		√	√	√	√
12. Backlash with rolling fixture or pins		√	√	√	√
13. Pitch diameter with three wires of thread, any form	√		√		
14. Plugs, arbors, precision parts, as a comparator	√		√		

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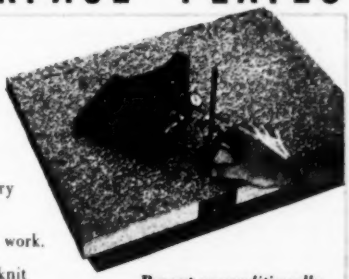

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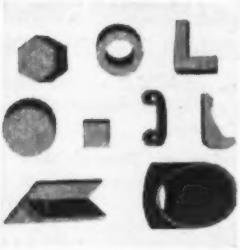

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